THE SOIL SCIENCE SOCIETY OF FLORIDA

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PROCEEDINGS
VOLUME VIII
1946

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Annual Meeting Of The Society
West Palm Beach and Belle Glade
April 4 and 5, 1947

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ACKNOWLEDGMENTS

The gratitude of the Executive Committee and of the entire membership of the Society is extended to Dr. R. M. Salter, Department of Agriculture, Washington, and to Dr. C. F. Huffman, Michigan State College, East Lansing, for their appearance as Guest Speakers before the Society and for their fine part in the program; also to Mr. Wade Linder and his associates for their fine cooperation in making the facilities of their fine hotels, Pennsylvania and George Washington, available for the meetings; to the Staff of the Florida Agricultural Experiment Station for extending the use of the newly constructed Fiber Laboratory at the Everglades Station for the holding of the Ramie Symposium on Saturday morning; and, finally, to the fine group of sustaining members in the Society whose loyal interest in and support of the work really make the publication of the Proceedings possible in a creditable way.

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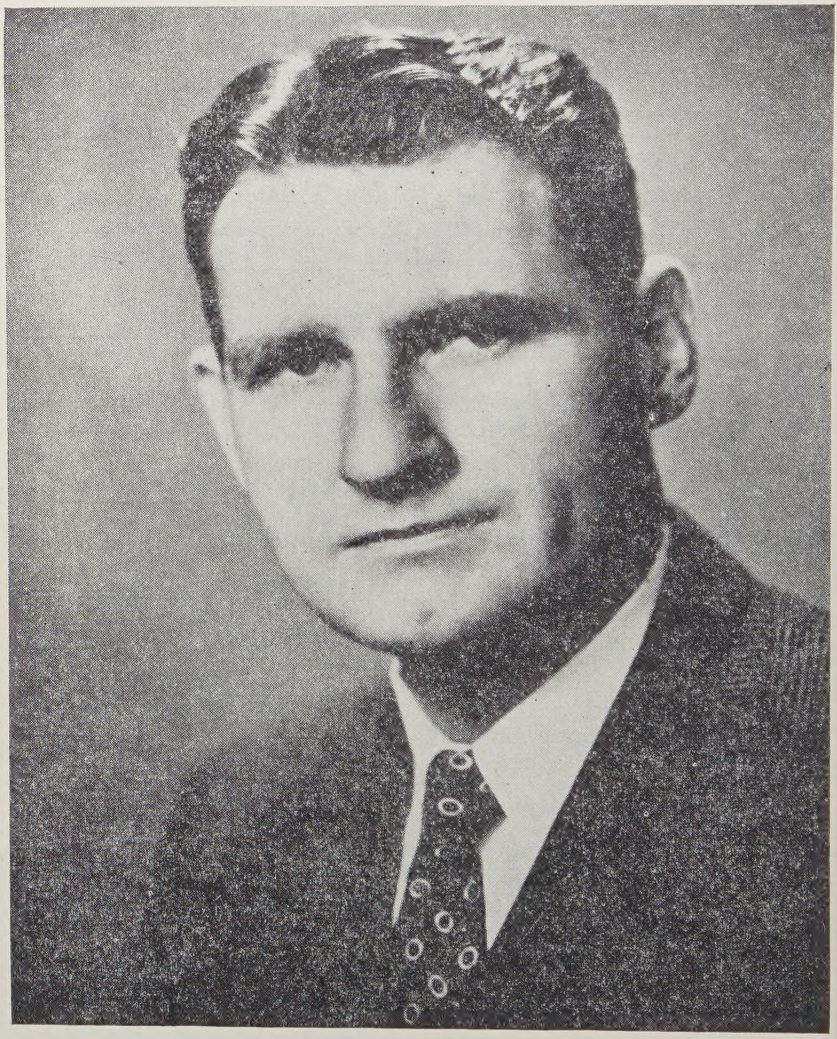

MILLARD F. CALDWELL

DEDICATION

THE HONORABLE MILLARD F. CALDWELL

GOVERNOR OF FLORIDA

(1945-1949)

Although his term as Governor has ended as this Volume goes to press and he has retired to private law practice in Tallahassee, the influence of Millard Caldwell is permanently impressed on Florida's future in soil and water conservation and control.

While Governor, he alerted the people of Florida to the need for intelligent planning in these fields. With matchless skill he welded those of divergent views into a unified and representative group of interested citizens whose militant support gives assurance that the far-sighted and comprehensive plan for water control and conservation will be accomplished.

The Soil Science Society of Florida, in recognition of his service in these great projects, respectfully dedicates this Volume of its proceedings to Millard F. Caldwell, formerly Governor of Florida.

GUEST SPEAKER

DR. ROBERT M. SALTER

A LOOK AHEAD IN SOIL AND CROP SCIENCE

Dr. Robert M. Salter*

I welcome this opportunity of meeting with the Soil Science Society of Florida. I must admit that I had expected to speak to a group of professional soil scientists, who, when we come together, talk "shop," often technical jargon understandable only to ourselves. I was interested, however, to discover that the membership of the Soil Science Society of Florida is composed largely of farmers, grove managers, and fertilizer men, with only a small part being made up of the professional soil scientists whose job is to study the soil problems of your State. It is gratifying to find farmers and growers interested in technical soils problems and that you take this opportunity of meeting together. It does, however, make it necessary that I discard my prepared "shop" talk, and try to discuss some aspects of soil research that I believe may be more interesting to the group.

Your Secretary suggested that I discuss both soil and plant research and some of their relationships. As a suitable background, and if you will pardon my rambling a bit, I would like to tell you something of what the farmers of this country have done within the past few years in accepting and putting into use the products of soil and plant research.

In World War II the scales of victory were finally tipped in our favor by superior technology and production. The phenomenal record of American agriculture looms large in the total picture of victory. The total volume of agricultural production was half again as large in the second World War as in the first, despite 10 percent fewer workers on the farm and no greater acreage of crop land. The volume of products per workers was 75 percent more, and the volume per acre 50 percent more than in World War I.

This miracle of increased production just could not have happened without the "know how" gained from the intervening quarter of a century of scientific research. In saying this I would not detract from the great credit due farmers, who, young and old, worked hard, long days under many handicaps. But we must not forget that it was scientific research that put into the farmer's hands the machines that were largely responsible for multiplying the output of his labor. It was scientific research that gave him crop varieties and soil management practices that permitted him to grow on 2 acres crops that required 3 acres in 1917. It was scientific research that increased the pounds of meat, milk, and eggs that he was able to produce from each ton of hay or bushel of grain. Research has been, and will continue to be, the basis for increasing the efficiency and productivity of American agriculture.

How, then, do we go about doing our research job? In much the same way that agricultural science is changing farming methods, we technicians are changing our approach to the job ahead. We are improving our techniques, and above all, we are learning to work

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together. In fact, the topic of my talk here tonight reflects the close relationship that exists between the soil scientist and the crop scientist. This community of interest does not stop with soil and crop scientists. It extends to the horticulturist, the animal scientist, the agricultural engineer, the entomologist, and the plant pathologist, and even to those working in most of the basic biological and physical sciences. The general objective of scientific endeavor presumably is to make the lot of man an easier one by contributing to his comfort, his health, and his longevity. In working toward this common goal it is only natural that there should be both need and opportunity for working together.

We workers in the fields of agricultural science recognize that we have made only a good start toward the maximum of effectiveness that should be possible through working together. But we have made a good start in bringing to bear the composite knowledge necessary to reach our research objectives. There are many notable examples. There should be more. One good example of the focusing of the talents of scientists in different fields on a common problem is corn production in the Southeastern States. This research appears already to have proved the possibility of increasing corn production to a conservative 50 bushels or more per acre on land that formerly produced less than 20 bushels. I will not review the history of this program but there are certain features of the work that might be emphasized.

In the first place, the soil scientists contributed the basic information about soils, about fertility control, and about certain tillage requirements. Developments of these features alone, however, was not enough to get the job done. Workers in the field of plant science contributed corn hybrids adapted to conditions in the South, and jointly with the soil scientists gave the necessary consideration to the matter of so spacing the plants as to give the soil a full plant load, with due regard to fertility and the moisture supply. Soil scientists, plant scientists, and agricultural engineers all have been concerned with the application of the principles of tillage, including cultivation for weed control and necessary consideration of possible root injury. The same groups have worked out methods for the placement of fertilizer at planting and for sidedressing with additional nitrogen at the time when the plant's need for this element is greatest. The entomologists and the pathologists have been brought into the picture where insects or diseases are limiting factors in corn production. Only by the simultaneous application of research talent in all these fields can the full potentialities for economic corn production in the Southeast be evaluated. Already the results appear to have justified the teamwork method of attack.

Research and Agricultural Education

This leads me to another matter about which I have thought a great deal, but, I am afraid, without coming to any very specific conclusions. In referring to the research on corn production we have assumed, I take it, that after we have developed the proper combination of practices required for the most efficient production, our job as specialized research workers is over and the next step lies in

the domain of those concerned with agricultural education. I wonder if we are fully justified in this assumption. Is it fair to assume that the extension worker and the farmer will pick up where we have left off and determine how our new method of corn production should be best fitted into the farming systems under the wide variety of conditions in the Southeast? I believe you will agree that up to now practically all agricultural research and, in fact, most farmer education and aid, have been concerned with the individual elements of production. The rational synthesis of these individual elements into balanced and efficient programs of management adapted to particular complexes of conditions has been left largely to the farmer to work out for himself. Perhaps we need to take a leaf out of the book of industrial research, where, following development in the laboratory, a new process is carried into the pilot-plant or semi-works stage in order that the problems involved in fitting the new process into the other factors of production may be developed. It seems logical to me that the integration of the elements of modern agricultural technology deserves both scientific inquiry and the application of technical competence as much as or even more than the development of the individual elements.

To make this matter more specific, the individual elements of production that must be fitted together in the operation of almost any farm include such factors as crop rotation, land drainage, liming, use of fertilizer, tillage for weed control and water conservation, erosion-control practices, choice of best crop varieties, proper timing of field operations, conservation and efficient use of manure, proper choice of farm power, and machinery, control of insects and crop diseases, livestock feeding, animal breeding for improvement, animal health, efficient structures for storing crops and housing animals and machinery, and many others. Synthesizing a system of management compromising a balanced and integrated combination of these individual elements properly geared to the physical resources of the land, to the agricultural economy of the area, and to the financial, managerial, and labor resources of the operator could, it seems to me, well receive the attention of the research specialists who working together would know most about these individual elements.

Of course, you might say this would be research in the field of farm management, and you would be right. In the past, however, I think it is fair to say that most research in farm management has had an analytical approach. The usual method has been to study the operation of existing farms and from an analysis of the various components in their operation to attempt to determine which were good and which were bad, or what combinations seemed to be giving best results. What needs to be done, it seems to me, is to approach the problem of farm management synthetically. How can we put together into systems of management fitted to specific conditions the best technology that the scientists in the different fields have to offer? I frankly believe that we need to develop research in this field of management working on a unit farm basis in the various types of farming areas and in a collective effort bringing to bear the competence of the research workers in the various fields. I doubt if any single individ-

ual, broadly trained as he may be, could be expected to do the type of job that needs doing. Thus, as we look ahead in soil and plant research it will not be surprising to find our research specialists in these fields working with specialists in the other agricultural sciences in a joint effort to fit their results into efficient systems of farm management.

Soil-Management Studies

Even greater opportunity for agricultural research lies ahead, since the Congress passed the Research and Marketing Act of 1946. Many of you are familiar with its details. I would suggest that you give it close reading, if you haven't already, for it lays the foundation for even wider cooperation in agricultural research.

What, then, is some of the forward thinking in regard to the Research and Marketing Act and the opportunity it offers to soil scientists? We all know that there is need for research into many phases of the soil problem. These would include the soil management practices that I have emphasized for more efficient crop production, including soil and water conservation, as related to soil types, climates, kinds of crops, rotation, tillage, irrigation, drainage, and fertilizing techniques. We should develop and evaluate the use of improved fertilizer and liming materials for economic and stable systems. And finally, we need to conduct basic studies on soil and plant relationships.

In my remarks I have dealt primarily with applied research, because a major part of our investigations falls in this field. But fundamental research is of no less importance, because it provides the foundation on which a large part of applied research is built. The farmer and the rest of the public often see only the results of applied research. Naturally, when public money is appropriated for scientific inquiry the stress is given to that form of research which they as stockholders in our scientific institutions can see and evaluate. But without fundamental concepts, applied research can progress only within certain circumscribed limits. A broader understanding of nature and its laws is basic to further progress.

Practical Application of Fundamental Research

This does not mean that we must have all the fundamental answers before we start a project in applied science. As a matter of fact the practical application of research often points out the gaps in fundamental knowledge. It is these gaps that must be constantly buttressed if we are to build a sound and lasting research program.

For example, a little more than 10 years ago, our plant scientists at the Plant Industry Station became convinced that some of the fundamental physiological functions of plants needed to be clarified to hasten certain objectives. Such an inquiry was begun and was first known as the hormone project, because the scientists assigned to the task were concerned with the role of natural plant hormones.

An early problem in this work was how to obtain even the minute quantities of natural plant hormones that were needed for treating plants in the laboratory. While studying these natural plant hormones, other scientists found that certain complex chemical compounds produced hormone-like effects on plants. Then turning to

and applying these chemicals to plants revealed many interesting and practical uses. In the last 10 years Bureau and other scientists working on this particular project, particularly those of cooperating State agricultural stations, have brought forth many revolutionary uses for what we now call plant-growth regulators.

First it was found that a strictly female plant, such as the holly, could be induced to fruit without pollen from the male plant. Then came simplified means to induce rooting on hard-to-root cuttings. More outstanding and immediately practical discoveries came with the introduction of stop-drop sprays for fruit, 2, 4-D as a selective herbicide, and compounds to hasten the ripening of certain fruits, to prevent potato sprouting in storage, to eliminate storage losses of apples through control of scald, and to produce heavier sets of fruit on green-house grown tomatoes. Many other possible uses still in the laboratory stage hold great promise.

A number of research institutions both here and abroad are now working on plant-growth regulators. Some 2,000 synthetic compounds have been tested one way or another and more than 100 of these are being used actively in research.

The investigations in this field point up one of the peculiarities of basic research. It has opened a variety of paths that lead to productive advance. Certainly, those who planned the project could not foretell 10 years ago what some of the end results would be. Such basic projects provide the scientific capital upon which we draw funds for practical applications of knowledge.

Strangely enough, research in such a fertile field brings with it the temptation to turn from the original intention to the immediately profitable byways of applied research. Under the flexible system we have in agricultural research, however, we can do both, and it is being done. With 2,4-D, for example, those engaged in the fundamental work pass on to the weed specialist the general principles for its practical development, and then turn once more to the fundamental problem. The weed specialist obtains the cooperation of the combined forces of the weed specialists at the State experiment station. Working together, they apply the research under many different sets of conditions that operate to broaden the scope and hasten the day of practical achievement.

Research for Crop Improvement

As we look ahead in plant science many opportunities can be seen for improving the crops the farmer grows. Not the least of these is utilization of hybrid vigor, or what the plant scientists refer to as heterosis. Despite the stride already made with hybrid vigor in corn, the plant breeders know that they have penetrated only the fringe of this natural phenomenon. Production of hybrid onions has followed the initial success with hybrid corn. Here again the story of hybrid vigor is expressing itself in yields up to 50 percent greater than those of ordinary varieties, with greater uniformity in size, with greater resistance to disease, and with an unusual uniformity in size that makes possible nearly 100 percent U. S. No. 1 grade.

While the development of hybrid vigor in onions closely parallels that of corn, there was one decided difference in the research

problem. Because the flowers of most plants, unlike corn, contain both male and female organs, there was no feasible mechanical means of clipping pollen-bearing stamens to prevent self-pollination and assure a pure cross. With corn this is a relatively simple process, as the tassels are pulled from the plants of one of the parent varieties, thus assuring a pure cross. The key to successful hybridization of onions came with the discovery of a male-sterile plant, one that would produce seed only when fertilized with pollen from another plant. It was, in effect, a female plant and for breeding purposes was the same as detasseled corn.

After years of intensive study, methods have been worked out whereby two breeding lines are carried along for each variety intended for use as the female parent. One line is male-fertile, and the other is male-sterile and is maintained by backcrossing with the fertile line. This backcross makes it possible to maintain and produce the female parent line used in production of hybrid seed—thereby laying another foundation stone of fundamental research.

Scientists working with alfalfa and sugar beets and using the same fundamental principles have produced vigorous hybrids. Neither hybrid alfalfa nor hybrid sugar beets has yet reached commercial production, but both are only a few short years away. Alfalfa strains that are completely self-sterile have not yet been obtained, but in some strains now at hand male fertility is so low that at least 90 percent of the field crosses are pure hybrids and yield tests have been extremely promising. Scientists have shown that they can get 100 percent hybrids with sugar beets in the same manner as with onions. The experimental hybrids have shown high disease resistance, and the yields have exceeded those of leading commercial varieties by 2 tons per acre and 11 percent in sugar.

Having captured hybrid vigor with corn, and having demonstrated the possibilities of its commercial development with alfalfa, onions, and sugar beets, the plant scientists are now working toward the same goal with other crops where heterosis has been expressed experimentally. Other means of approach to greater and more efficient production also are known in which the final results may be just as promising.

For several years plant breeders have been successfully breeding plants resistant to or tolerant of insects and diseases. We have brought disease-resistant plants from the far corners of the world to this country in order to incorporate their resistance into our own varieties. For example, we obtained a higher resistance to fusarium wilt in the tomato by importing a wild tomato, no larger than a marble, from the high Andes in South America. This wild tomato had no economic value, but when crossed with our domestic varieties it provided the germ plasm that gave our tomatoes increased resistance to this disease.

An even more interesting offshoot of this work came about when our scientists suggested that extracts from disease-resistant plants may have some therapeutic value. Extracts from tomato vines have been made into an antibiotic that is being studied in cooperative work with the Medical School of Duke University as a possible specific for certain skin diseases.

On the way down to the meeting we had the opportunity of visiting the Southeastern Regional Vegetable Breeding Laboratory, at Charleston, South Carolina. We saw there a very interesting development in strains of peas resistant to cold weather. The cold wave of February 17 saw the temperature at the Charleston station drop to 18 degrees F. Common garden varieties of peas suffered nearly 100 percent damage, whereas some strains of new peas suffered little or none. Strangely enough, some of the cold-resistant varieties also do better under hot weather conditions.

These samples do not cover all the new developments in plant breeding by any means, but do furnish examples of what is ahead in plant breeding.

Studies of Soil Properties and Processes

As we look ahead in soil research one phase that promises much for the future is in the field of soil physics. We are just beginning to understand the relation of soil structure to soil aeration and the influence of soil aeration upon the respiratory activity of plant roots, and this in turn upon the ability of the plant to absorb water and mineral nutrients. We do know that, lacking sufficient oxygen for normal root respiration, some plants are incapable of taking in adequate quantities of water and of some of the mineral elements, especially potassium; also that the oxygen requirements of plants differ greatly. Some of you have doubtless seen tobacco wilt or "flop" when the soil became water-logged from too much rain. Other plants behave the same way. Recent work in Iowa has showed that some crop plants on tight or puddled soil are unable to absorb enough potassium although the same plants growing on the same soil in a well-aerated granular condition could get all the potassium they need. It is well known that such crops as potatoes and sugar beets are particularly sensitive to lack of air in the soil. When our soil scientists are able to determine how much pore space or what kind of soil structure is best for a given crop, and then what methods of management or tillage are necessary to achieve the desired structure, many of our baffling problems of crop production will be solved.

Another intriguing field for research lies in the realm of soil microbiology, especially in the possibility of developing methods of controlling the micro-flora of a soil in such way as to make use of the ability of certain soil microbes to produce antibiotic substances that may kill or control other soil organisms that cause crop diseases.

You are all familiar with the remarkable ability of penicillin, produced by a common bread mold, to kill various disease organisms affecting man and animals. Another antibiotic, streptomycin, equally effective against a different group of disease organisms, is produced by soil organism isolated by Dr. Waksman of the New Jersey Station. It seems entirely plausible that, among the myriad forms of micro-organisms inhabiting our cultivated soils, some may be able to produce powerful antibiotic substances that might kill off pathogenic organisms preying on our crop plants.

Of course, ways would have to be developed for stimulating the growth of the particular antibiotic-producing organisms in the soil. This may not be so difficult as it seems. Already a serious disease

of cotton, the Texas cotton root rot, has been successfully controlled by incorporating in the soil at the proper time organic matter of high nitrogen content. Although the specific organisms involved are not known, the effect seems to result from a flush growth of certain groups of soil organisms that produce some substance that kills and rots the spore-bearing sclerotia that remain in the soil after diseased cotton is harvested and infest the succeeding crop.

We are hoping that some similar technique may be effective in controlling the sclerotinia rot of beans and tomatoes that has become so destructive in Florida, and Dr. Moore, of our Bureau, is working on this problem. There is reason to believe that some of the soil-borne diseases affecting tobacco may yield to this method of attack. In fact, the possibilities of research in this field may extend to a great many of our important crops.

Fertilizer Research

A new tool that we are now using in soil research is radio-active phosphorus, provided to us by the Government's plant at Oak Ridge, Tennessee. Using radio-active phosphorus we have just completed controlled laboratory tests that have told us accurately for the first time, just how much phosphates used by plants are coming from applied phosphates and how much from natural phosphates in the soil. This new tool should give us further insight into the availability of applied phosphates and the tendency of phosphatic fertilizers to become "fixed" in the soil. The tests will be carried to field trials this spring.

One of the latest developments in fertilizers has been the development of a slow-acting nitrogen fertilizer that feeds crops over a long growing period. It is an insoluble inorganic material known as Uraform, made from combining urea and formaldehyde and is produced at present only on a laboratory scale. So far, the results indicate that Uraform is superior to natural organics in supplying nitrogen at a uniform rate over a long growing period. Unlike other inorganic nitrogen now in use, it does not leach out of the soil easily. It offers promise as a source of fertilizer for corn, potatoes, tobacco and crops whose need for nitrogen continues for a long period after planting. Its prolonged action and durability also make it a valuable fertilizer for turf and other grasses. Because it does not appear to be affected by moisture absorption, Uraform offers possibilities as a conditioner to prevent caking in mixed fertilizers.

Unfortunately, both urea and formaldehyde are in short supply at this time. As a result Uraform must wait until these chemicals are again available.

It has been a pleasure to meet with you. It is a pleasure, too, to see the interest of the farmers and growers in agricultural research. We have not, by any means, reached the limits of what science can do for farmers. With your interest and support we can do a better job.

Symposium I: SOILS IN RELATION TO ANIMAL NUTRITION

Hotel Pennsylvania, West Palm Beach, April 8, 1947 9:30 A. M.

Dr. C. F. HUFFMAN

Dr. Huffman was born in Kansas in 1893 and took his BS, MSc and PhD degrees in Kansas, Minnesota and Wisconsin, respectively. He was first Instructor in dairying at Kansas State and subsequently Assistant Professor in the same subject in Minnesota from 1921 to 1922. He then went to Michigan State College where he became a Research Associate and later Research Professor, the title which he now holds.

The Borden Award was given Dr. Huffman in 1937 for outstanding work in animal nutrition. His exceedingly careful and thorough work with the role of calcium, phosphorus, magnesium and fluorine in nutrition and his extensive work with cottonseed meal and with dietary factors carried by hay and of the vitamin D requirements of cattle give Dr. Huffman a fine background of study and experience from which to draw in the treatment of the subject in hand which is of such very great interest to all cattlemen in South Florida, beef and dairy alike.

THE ROLE OF TRACE ELEMENTS AND VITAMINS IN ANIMAL NUTRITION

Dr. C. F. Huffman*

It is a great pleasure for me to have the opportunity of visiting the Everglades. Many years ago, it was my privilege to make my home at Loxahatchee with Alf Nielsen. I marvel at the progress that agriculture has made which speaks well for the very fine work of the Florida Experiment Station at Belle Glade and Gainesville.

There are few places in the United States like the Everglades when it comes to the possibilities of increasing livestock efficiency through pasture production. Also, pasture properly managed furnishes the basis of adequate rationing—plenty of most of the essential dietary factors harvested by the animals themselves. Then too, sod crops aid in maintaining soil fertility in many ways.

Trace Elements

Heavy roughage consuming farm animals are more likely to suffer from mineral deficiencies due to the fact that the vegetative part of the plant is more subject to variation in nutritive value than are the seeds. Some of the nutritional deficiencies of farm animals are related to the effect of soil conditions on the chemical composition of plants while other deficiencies are only indirectly affected by soil conditions through plants.

Some of the nutritional disturbances of livestock may be the result of depletion or primary deficiencies in the soil, the unavailability of mineral elements or to weather conditions prevailing during the growing season which prevents plants from taking up sufficient minerals. Then too, certain species of plants have the ability to take up more of certain mineral elements than others grown under the same environmental conditions. Also in most regions, livestock is restrained by fences to certain rather limited areas and consequently receive most of their ration from the same farm from generation to generation and may eventually reflect the soil conditions on that farm. This may account for the occurrence of mineral deficiencies on certain farms and not on others in the same locality.

The trace elements known to be needed by animals are iron, copper, cobalt, manganese, zinc and iodine. Although it is customary to discuss iron first, I would like to break the tradition by starting with cobalt.

Cobalt was recognized as a mineral during the time of Solomon, but it was associated with gnomes and evil spirits. As a matter of fact, it was not until 1935 that cobalt became classed as an essential element. For years wasting disease had affected cattle and sheep in many lands under a variety of names: "Marasmus" in Australia; "bush-sickness" and "Morton Main's disease" in New Zealand; "pine" in Scotland; "salt-sick" in Florida; "Grand Traverse" or "Lake Shore" disease in Michigan and "Burton-ail" in New Hampshire.

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Fig. I. A milking cow suffering from cobalt deficiency. Poor condition due to lack of appetite for grain and roughage.

Fig. II. The same cow as in Fig. I, 16 days after starting cobalt feeding. Milk production also increased.

This classical research work carried on simultaneously by investigators in New Zealand and Australia resulted in the discovery of the value of a few milligrams of cobalt daily in the ration as a cure and preventive of the wasting disease which had baffled livestock men in many regions of the world. In 1925, Shealy of Florida showed that "Salt-Sick" in cattle was corrected by feeding feeds grown on other areas. In 1931 the Florida workers reported that the supplementation of the ration of affected cattle with iron and copper resulted in recovery. Becker, Neal and Gaddum in 1937 showed that cobalt deficiency was a causative factor in "Salt-Sick".

The Michigan Agricultural Experiment Station started an investigation of a wasting disease among cattle along the shore of Lake Michigan in 1904. This disease was called "Grand Traverse" or "Lake Shore" disease. Affected cattle brought to East Lansing responded to the change in ration and environment. The conclusion was reached that the cause of the trouble was insufficient nutrients. No doubt the improvement in health was due to the linseed meal fed, which we now know to be a good source of cobalt.

One of our Michigan dairymen read the account of cobalt work conducted in New Zealand, Australia and Florida in the 1939 U. S. D. A. Yearbook. He fed cobalt to his herd which responded by a marked increase in appetite and well-being.

We carried on controlled experiments in many areas of Michigan and found that cobalt deficiency was the most common mineral deficiency in the state. We later studied the cause of a lack of thrift among cattle in the Upper Peninsular of Michigan where cobalt sup-

Fig. III. Heifer chewing wood fence, a common form of depraved appetite sometimes associated with either cobalt or phosphorus deficiency.

plement really went to town. The raising of cattle in this area was revolutionized by the use of a trace amount of cobalt.

The symptoms of cobalt deficiency in sheep and cattle are varied, but usually consist of a lack of appetite followed by stunted growth, decreased milk production, and eventually emaciation. Although depraved appetite is often observed, it is not a reliable criterion of cobalt deficiency. As a matter of fact, depraved appetite is of little diagnostic value, since it is probably a manifestation of nervous irritability and may be due to many different causes. For instance, wood chewing and dirt eating are frequently observed in cattle which are apparently healthy. Up to now most cases of depraved appetite occurring in animals with a good appetite for feed have failed to respond to mineral supplements. Occasionally a "tongue shaker" or a "tongue loller" responds to large doses of cobalt, but most cases do not respond to any mineral supplement thus far used.

Although most animals suffering from a lack of cobalt show anemia, yet we frequently observe improvement in appetite in cattle with a normal hemoglobin and red cell count. Since ruminants are more prone to suffer from lack of cobalt, the theory has been advanced that the rumen microflora (bacteria) may require cobalt. Workers in Australia reported that the injection of cobalt into the blood stream did not bring about recovery of affected animals. Dr. Comar and Dr. Davis of the Florida Experiment Station injected radio active cobalt into the blood of a rumen fistula cow. No significant amount of this element passed into the rumen. We were very happy to furnish the rumen fistula cow used in this work. These data suggest that the rumen is where cobalt does its work.

Cobalt deficiency in livestock appears on a variety of soils of widely different geological origin, such as the pumice and granite soils of New Zealand, the shell sands of South Australia and the glaciated soils of Michigan. The evidence shows that the application of cobalt to unhealthy soils increases the cobalt content of the herbage in an amount to meet the needs of cattle and sheep. In view of the fact that cobalt is not required by plants, it may be more desirable in most cases to administer cobalt supplements to animals.

The classical use of iron and copper for the treatment of pig anemia is the only instance where iron has been proven to aid in livestock production. Most of the earlier work which indicated that iron deficiency resulted in unthriftiness among ruminants can be explained on the basis of the presence of cobalt and-or copper as an impurity. We have observed low hemoglobin values among young calves on certain farms in Michigan, but these animals appeared healthy, and at the age of about four months recovered without treatment.

The first published report which indicated that copper deficiency occurs naturally in ruminants was that of Neal, Becker and Shealy in 1931. Copper deficiency was later observed among cattle in certain areas in Holland, Australia, New Zealand, Scotland, Sweden and South America. Copper deficiency occurred also among sheep and goats, and occasionally among swine and fowl.

Copper deficiency symptoms appear to vary from country to country and with the animal species affected. The disease in sheep

may be manifested by wasting disease, ataxia (swayback) in lambs, and "stringy" wool of any age. Breeding ewes may become anemic and manifest diarrhea. Anemia, although commonly present in subacute cases, is not always present. There is no anorexia.

A symptom of copper deficiency in cattle in Southwest Australia is "sudden death" or "falling disease." The clinical symptoms are loss of condition, rough coat, and evidence of anemia. Depraved appetite is common. Diarrhea is not a symptom of copper deficiency in this area. Suppression of estrum and temporary sterility in cows were attributed to copper deficiency in this area. Stunted growth and limb abnormalities occurred in calves. According to Neal the symptoms of copper deficiency in cattle are anemia, diarrhea, loss of appetite and depigmentation of the hair.

It appears that copper deficiency in livestock may occur on pastures well supplied with copper because of factors affecting the availability of copper to the animals. An illustration of this is the "scouring disease" in cattle due to high molybdenum in the pasture.

The toxic effects of too much molybdenum is believed to take place in the digestive tract. Since only ruminants are affected by too much of this element, its relation to rumen bacteria is indicated. Fortunately, copper sulfate administration counteracts the bad effects of molybdenum. Although on some soils plants take up more of this element when neutral or alkaline, yet on other soils the reverse is true.

The occurrence of other symptoms of copper deficiency before the occurrence of anemia, and in some cases the non-appearance of anemia, suggest that the function of copper in ruminant nutrition is not restricted to its hematopoetic effect. A role in rumen fermentation appears likely.

Manganese is one of the dietary factors required by most an-

Fig. IV. These four large hair balls were taken from the rumen of a two-year old heifer which had manifested craving for hair either from her associates or from her own body.

imals. A deficiency results in perosis and poor hatchability in poultry, lameness in pigs and muscular weakness in cattle. Manganese supplements are needed in the poultry ration of birds kept in confinement. Manganese deficiency in other farm animals has not been observed under farm conditions.

Goiter occurs in newborn cattle, sheep, goats, horses and pigs. This disease has been observed on a variety of geological formations. There are many factors other than a low iodine intake which operate to produce goiter. Attempts to correlate the incidence of goiter with the iodine content of pasture and hay feed have not been entirely successful.

Vitamins

Although farm animals require most of the recognized vitamins, the common productive rations fed furnish most of them except for poultry. Pasture and the solar radiation that goes along with it does a grand job of meeting the vitamin needs of farm animals.

Vitamin A which is made in the animal body from carotene is required by farm animals, but they have the ability to store large amounts of this vitamin during the pasture season. Consequently, it is difficult to produce vitamin A deficiency in the ruminant. We have not observed vitamin A deficiency among cattle of Michigan under farm conditions for this reason. The lack of vitamin A is manifested in cattle by increased spinal fluid pressure, which in turn results in injury to the optic nerve. Complete blindness results. Vitamin A supplementation does not prevent scours in young calves as pre-

Fig. V. A lack of vitamin A in the ration of the mother resulted in the birth of this weak and blind calf. A good pasture program takes care of the vitamin A needs of livestock.

viously assumed, but may be of some value as a treatment due to the increased requirement during infection.

We have made a study of the vitamin D needs of cattle. Solar radiation takes care of these needs during the spring, summer, and fall under Michigan conditions. The use of sun-cured hay supplies enough vitamin D for winter conditions. It is evident that vitamin D is not a problem among livestock in a sunny state like Florida.

Fig. VI. Rickets due to lack of sunshine and-or sun-cured hay.

The vitamins making up the B-complex, thiamine, riboflavin, niacin, pantothenic acid, biotin, inositol, and folic acid are synthesized in the rumen. Vitamin C is synthesized by the tissues of farm animals. We have observed a few instances where cattle for some unknown reason were unable to make as much as they needed. These cases, however, are believed to be rare.

THE INFLUENCE OF TRACE ELEMENTS ON ANIMAL NUTRITION UNDER EVERGLADES CONDITIONS

Mr. R. W. Kidder*

Mineral nutrition in its several phases constitutes the most important and, in some respects, the most obscure problem for successful cattle production on the muck and peat soils of Southern Florida. Since saw grass peat soil in its natural state contains less than 10 percent of ash, a large portion of which is lime, it is easily understood that profitable crop production is dependent on the addition of minerals as fertilizers and that deficiencies of trace elements might be expected under such conditions. It has been a comparatively easy problem to find out what fertilizers were essential to obtain large yields of forage after the fundamental necessity for copper was established. However, our records indicate that the minimum amount of copper necessary to make grass grow is not necessarily enough to satisfy the needs of an animal grazing on pastures so treated. Phosphorus and perhaps other essential elements also may be present in too small amounts even though the yield of grass is high. So the problem becomes one not only of securing maximum yields of forage but of making this forage capable of producing healthy animals by supplying the necessary amounts of all the essential elements.

There are at least five ways of getting the animals to take these essential minerals. Some elements are most economically applied as fertilizer to the pastures because they influence yield as well as quality of forage. Phosphorus and copper are included in this group.

Another practical method is to include these minerals in the salt mixture which is made available to the cattle at all times. Some individual animals fail to consume sufficient minerals from the salt box and for lack of a better method it has been found necessary to drench these with mineral solutions or in some cases, the minerals have been successfully added to the drinking water. Experience has shown that some pastures produce healthy cattle while in others, nearby, cattle become affected by nutritional disorders. Hence, the rotation of pastures has been practiced in Florida for many years as a cure or prevention for malnutrition. A similar effect can be obtained by bringing supplementary feed to the cattle from other localities or regions.

In the Everglades region the entire area of organic soils originally produced symptoms of malnutrition to such an extent that all of the livestock ventures prior to 1930 ended in failure. When the cattle project was first started at the Everglades Station in 1931 and 32, visitors on several occasions told us that cattle would never be successfully produced in this area. Even after 5 or 6 years the records were not too encouraging, but they did show the seriousness

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of the problem and at least some of the factors which made up the record. The most serious of those factors pointed definitely toward mineral malnutrition as the underlying cause of most of the trouble.

During recent years these problems have been solved to such an extent that this area, which contained scarcely more than a few family cows 12 years ago, now maintains approximately 15,000 head.

Symptoms of Mineral Malnutrition

The symptoms of malnutrition of the type which have been mentioned, are quite variable due to age of the animal affected, to individual resistance or susceptibility, to variations in soil treatments, or to after-effects of diseases like anaplasmosis or various forms of parasitism. Some other conditions, which are only partially understood, may also cause variations in the combinations of these symptoms of malnutrition.

The commonest complaint is that cattle scour excessively when grazing muck pastures. Our experience has shown that some calves have this diarrhea at or soon after birth and others develop it within the first or second month. It also affects cattle of all ages and, because coccidia were usually present in fecal specimens, the problem was treated as coccidiosis for several years without obtaining more than partial control. Many calves died when 2 to 8 weeks old and others were retarded in growth. Sanitary precautions certainly were in order and observed but the scouring persisted.

Those calves which survived the diarrhea developed a faded or bleached hair coat which was also characteristic of a large number of the mature cattle. This bleaching of red to almost a yellow and of black to grey is easily seen but not so easily recorded or measured. Attempts have been made to preserve hair samples, to make color photographs both in sunlight and artificial light and to make comparisons on standard color charts. The sun-light color films have made the best records particularly when two animals, one bleached and one normal have been photographed together to obtain the contrast.

Along with this bleaching and diarrhea many of the calves were lost with broken bones usually when about 2 to 6 months old but sometimes older. Two typically severe cases are those of two grade calves slaughtered on July 28th 1934. The record shows that one calf had a broken pelvis on the left side and a broken humerus on the right and all but 4 of his ribs either were broken at the time or had been broken. The other calf had a broken left tibia and only 3 sound ribs. These rib bones were easily cut lengthwise with a butcher knife. Some of these injured calves were kept alive until their broken bones knitted. A few developed infections and could not be saved. Several calves born with severely deformed bones showed that the condition could also be congenital.

Some calves and many of the older cattle developed a peculiar gait, similar to that of a pacing horse, when the scours and diarrhea persisted. Hence, this phase of the trouble was called "Paces" by the cattlemen. "Pacing" animals often become extremely nervous and frequently offer to fight rather than allow themselves to be driven.

Animals in all except the very final stages before death con-

tinued to eat whatever feed they were accustomed to. Some have even consumed a reasonably good fill of grass within 3 or 4 hours of death. This is in contrast with other conditions where the animal loses its appetite completely.

Other signs of the beginning of nutritional disorder are the enlargement of lymph glands, particularly the prefemoral glands which become quite prominent, and the formation of ring-like growths at the lower end of the cannon bones above the ankles.

Postmortem examinations have shown the flattening of the ends of the long bones of the leg in the joints, which would help cause a jerky gait. Many cases also have shown a cleavage or separation of the periosteum from the scapula. Some have also had an inflamed or bloodshot condition at the junction of the bone and cartilage along the upper edge of the scapula.

Some animals show very little outward appearance of being abnormal though increase in weight stops, while some forms of maturing continues, as shown by horn growth and appearance, but the weight may remain nearly the same for 6 months to a year.

A few animals have been observed to eat the muck soil as one would expect them to eat a grain ration. This depraved appetite is not general but indicates that even normal looking animals may be craving something that is not in their daily diet.

Cases of hair loss, spoken of as a depilatory effect, have been observed. These animals usually have become bleached and show some of the other deficiency symptoms. Why this condition appears so infrequently is not understood.

Cattle in this region often are seen with skin sores. One type, which usually appears in the naval region, responds to treatment with a saturated solution of hypo (sodiumthiosulfate). Another type which starts like a blister can be cured by the anaplasmosis treatment—intravenous injection of sodium cacodylate. A third type of of sore characterized by a thickening of the skin often appears on the sides of the neck but may also be found over the ribs or abdomen. This type of sore does not respond to antiseptics, is not susceptible to screw worm infestation and must cause itching because the affected animal licks or rubs the affected area. We consider these sores nutritional because among one group of cattle moved to a pasture on Paines Prairie these sores disappeared. Similar cattle have been moved to other locations on different soils where the sores persisted for several years.

Breeding difficulties are not uncommon. Whether there is more of this type of trouble in South Florida than elsewhere is uncertain.

Effects of Cottonseed Meal

During the winter of 1934 and 35 when pasture was short, the native cattle in the Everglades Experiment Station herd were fed freshly cut sugarcane. These cows lost weight on the sugarcane alone but gained rapidly when cottonseed meal was added to the ration. The improvement in general appearance of these animals was thought to be greater than could be explained by the protein balance which the cottonseed meal provided. Furthermore, the cows again

began to show symptoms of malnutrition as soon as the pasture became abundant and the feeding of cottonseed meal was discontinued. Several other similar observations were made regarding the beneficial effects of cottonseed in assisting to correct these nutritional disorders. Feeding trials in 1936 continued to substantiate these records, therefore, a policy was adopted to feed one pound of cottonseed meal per head daily to the young animals from weaning time or a little earlier until they approached maturity. This program has saved the Devon herd at the Station until we could more thoroughly study the mineral nutrition problem. It is essentially the same approach to the problem as the rotation of pastures which has been practiced for years by Florida cattlemen.

Importance of Phosphate and Other Fertilizers

Early results from grass plots fertilized at different rates showed that the most economical yields of grass could be obtained by treatments of copper and potash. From this it was considered advisable to treat the pastures with only these two fertilizers. After several years of work with these grass plots, samples were analyzed chemically and it was shown that the plots receiving copper and potash treatments developed a serious deficiency in phosphorus after the first year. When 0.3 percent of P_2O_5 is recognized as the minimum content required to produce healthy cattle, these potash plots after the first year produced grass as low as 0.21 percent P_2O_5. A revision of the fertilizer treatments on the pastures which included phosphorus has helped reduce the occurrence of soft and broken bones in the herd.

Manganese was also tried as a fertilizer, without obtaining any obvious benefit to the animals grazing on pasture so treated. In fact, this one trial seemed to show an injurious effect which could have come from some cause other than manganese.

In March 1943 a group of grade Devon cows were put in a pasture that had been fertilized for maximum production of grass. While the stand of grass obtained was not very good the quality of the grass maintained these animals until October 1945 in a condition that seemed quite normal. A pacing steer added to this group soon became normal without receiving any other treatment.

Results of Supplying Various Minerals in Drenches

The mineral elements that have been studied as drenches, injections, feed mixtures or additions to drinking water include arsenic, phosphorus, manganese, molybdenum, cobalt, iron, copper and aluminum.

Because sodium cacodylate is an arsenical compound and showed benefits to the health of animals affected with anaplasmosis and in curing one type of skin sores, arsenic was used in a series of experiments. In these trials, running from June 14 to September 16, 1938, some animals were given sodium cacodylate intravenously, some received daily drenches of sodium arsenate and some were drenched with copper sulfate. No significant results were obtained from arsenic as measured by changes in live weight or hemoglobin reading made on the Dare instrument. A slight stimulating effect

was noted from the arsenic but this was not considered a nutritional benefit.

Because a rachitic condition can develop from an abnormal balance of phosphorus and calcium, and the calcium content of the forage was known to be high, phosphorus was supplied to one group of cattle as sodium phosphate while a matched group was used as a check. The check lot excelled the sodium phosphate lot in rate of gain and hemoglobin readings. Blood phosphorus determinations on these animals varied from 6.10 to 8.55 mg. per 100 cc blood. Phosphorus deficiency symptoms develop when the blood phosphorus is less than 4 mg. per 100 cc blood. There was no consistent difference in blood phosphorus between lots.

Manganese was supplied to one cow in a dry lot at the rate of 500 mg of manganese sulfate daily for 5 months in her drinking water. No injury or benefit was apparent. At the same time 2 other cows received 200 mg. of manganese in their drinking water for the 5 months period without showing any measurable change in their physical condition.

Some of the symptoms of molybdenum toxicity, reported by the Wyoming Experiment Station in their work with selenium, seemed to be similar in some respects to those which appeared locally. A few samples of grass analyzed for the element were found to contain molybdenum in variable amounts. This element, which has had a prominent position in the problem for about 10 years, will be discussed later by Mr. Erwin. The interesting point relative to molybdenum toxicity is that treatments with copper sulfate will cure or control it. This has been demonstrated in the Somerset area of England. The symptoms of molybdenum toxicity are not easily distinguished from the symptoms of copper deficiency and, of course, under some conditions, may be identical.

Cobalt, when used alone as a drench at the rate of 10 mg per animal daily for 4 months had no visible effects on a cow in the late stages of paces. Both the cow and her calf died. Cobalt is included in the recommended salt mixtures because many cattle are deficient in cobalt when they are brought into the Everglades from other Florida ranges.

Iron has been used in experimental drenches as iron and ammonium citrate and in the "salt sick" lick as red oxide. While cattle invariably ate the mineral mixture containing 25 pounds of red oxide of iron to each 100 pounds of salt in preference to plain salt, we have found that they consume more of a salt mixture containing no red oxide of iron or smaller amounts than of the mixture containing 25 pounds per 100 pounds of salt. Since the symptoms of iron deficiency as described by Dr. R. B. Becker in Florida Bulletin 231 are different from those found in cattle on the muck pastures, and since the drenches of iron and ammonium citrate have not successfully cured this condition, the addition of iron to the ration is not considered essential for the Everglades.

In the fall of 1940 several experiments were conducted on the use of aluminum salts as drenches in controlled amounts. Two trials involving cattle from the Moore Haven area gave results which seemed to indicate that this element had produced a beneficial ef-

fect on the condition of the animals involved. Any response from aluminum alone in cattle in the Station herd was questionable. The best trial conducted with aluminum involved two pacing Hereford steers from Moore Haven which were brought to the Station and kept in a pasture together. The treated steer recovered but the untreated one remained a pacer for about 8 months before he died.

The addition of aluminum to the copper and cobalt drench seemed to improve the rate of recovery from diarrhea of the nursing calves. A drench consisting of 2 oz. copper sulfate, 2 oz. aluminum sulfate and ½ oz. cobalt sulfate to 1 gallon of water has controlled the scouring in nearly all calves that lived more than 4 weeks. A few calves have been lost during their first month and others have died at birth but the growth rate of the other calves has been improved by this drench each year since it was first used on the 1941-42 calf crop.

Copper Results

Copper seems to be the most important of the minor elements in controlling the nutritional deficiencies of cattle in the Everglades. Copper sulfate was used in small amounts along with the iron and ammonium citrate when the Devon herd was first established and probably was responsible for the small amount of benefit obtained from that drench. Copper sulfate was included in the first "salt sick" lick at 1 pound per 100 pounds of salt. When this amount was increased to 2 pounds there was a noticeable improvement in the condition of the cattle. In these early trials there was always a fear of producing copper poisoning by administering too large doses. The still larger amounts now being used effectively are known to be well below the lethal dose.

Copper sulfate for many of the better grasses is a necessary soil amendment. The amount required to make grass grow is small. However, treatments up to 25 pounds per acre have not supplied the cattle with enough copper to keep them healthy. When the rate was increased to 100 pounds per acre a curative effect was secured. Bleached and scouring cattle put on these pastures regained a normal hair color in 4 to 7 weeks. The diarrhea ceased within a few days.

In July 1939, 4 one-acre pastures were treated with 100 pounds of copper sulfate each. Eight bleached cows with their calves were put on these four pastures on August 11th. Definite improvement in hair color was evident by September 6th. Two of these pastures were given treatments of 100 pounds each of manganese sulfate in September. The four cows on the manganese and copper treated pastures remained in a bleached condition but all four of those on the 2 copper treated pastures had regained their normal healthy hair color by November 6th. A check animal was given 15 doses of copper sulfate, 1 gram each, during three weeks but failed to show improvement in hair color. The fear of developing copper poisoning led to the use of these small doses of copper. These two pastures treated with 100 pounds per acre of copper sulfate continued to correct the bleached hair condition in cattle for two years. The animals again developed bleached hair on these lots during the

third year. For this reason the application of large amounts of copper sulfate to the soil cannot be recommended as a general practice.

In January and February 1945 a 10 acre plot of virgin land was planted to St. Augustine grass without applying copper sulfate to the soil. A driven well and watering trough was located in the center of the area. In October, 10 grade Devon cows, two of them with young calves, were placed in this pasture. By January several of these animals were showing pronounced symptoms of diarrhea, and bleaching. The group was divided into 2 lots and treatments at 10-day intervals with copper sulfate at several levels given to one group. All of those treated in January began to show improvements at once and have been retained. Treatment of the other 6 animals was delayed until March and April at which time several of them were pacing and badly emaciated. An attempt was made to cure some of these with aluminum but it had no visible or measurable effect on the condition of the animals. Later treatment with copper was not effective in saving the animals on which treatment was delayed until April.

This copper work demonstrates that "paces" is caused by lack of copper in the grass and that it can be cured if treatment with copper is not delayed too long. If this copper deficiency is complicated in some locations by the presence of molybdenum, the problem may not be so simple. There is also the question of how aluminum fits into the program and whether or not cobalt also is beneficial when used with copper and aluminum.

So far there is no proof that copper is a factor in the stunting effect, depilatory condition, eczema-like, skin sores or whether or not there are nutritional breeding troubles present in the area.

PROPAGANDA FOR MINERALS AS A PREVENTATIVE AND CURE OF BRUCELLOSIS IN CATTLE

Dr. George K. Davis*

When brucellosis appears in the herd and some of the dairyman's best cattle are found to be reactors, the spectre of the entire loss of man's productive enterprise makes him want to try any procedure which promises to sidestep the slaughter of his animals. When the promise also includes the possibility that the other cattle of his herd will not be harmed, or perhaps even protected, then the temptation to try it out is very great. Under such circumstances, it is extremely difficult to be objective and evaluate the procedure in the light of what we know about brucellosis.

Since studies were first made of Bang's disease, as brucellosis in cattle is often designated, attempts have been made to cure or prevent its development in cattle through drugs or through changes in nutrition. The early literature is full of advertisement of materials guaranteed to cure Bang's, accompanied by testimonial letters telling how well this or that nostrum did the job of cleaning up the disease. A great deal of work was necessary on the part of careful scientists, who attempted to find out if any one of these materials actually did have some therapeutic or prophylactic value. Suffice it to say that none has been found efficacious in the treatment of Bang's or in its prevention. With the discovery of the value of vitamins, a new surge of advertising promoted the value of high planes of nutrition, particularly of vitamins, as a means of preventing or of curing Bang's.

At the Wisconsin Station, Dr. E. B. Hart and associates carried on an extensive experiment in which they carried the cattle on a high level of nutrition, including good qualities of alfalfa hay, minerals, cod liver oil, and salt, but they were unable to show any increase in resistance to brucella abortus when compared with the control group fed on frankly deficient rations. Similar results have occurred when tried with other animals.

For some years, manganese has been promoted as a preventative and more recently as a cure of brucellosis in cattle. More recently still, it has been promoted as a cure of undulant fever in humans. At some time in the last few years, copper and cobalt have been added to the mineral mixture which was supposed to have a beneficial effect. When Dr. R. V. Allison asked me to talk on the subject of minerals and brucellosis, I told him that I knew of no experimental work supporting the idea that minerals would prevent or increase the resistance of cattle to brucellosis. However, he insisted that what information we had of a negative nature should be assembled because it is so much in the minds of cattlemen in this part of Florida. I discovered that apparently the propaganda which is being circulated in the State at present is based on a paper report-

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ing the work of Irene Levis and F. H. Emory, which was entitled, "The Role of Minerals in Bang's Disease of Cattle". These works discovered that on the basis of spectrographical analysis, Bang's reacting cattle had considerably less manganese than normal. Upon reading this work, I noted that they call their results semi-quantitative and they found that those cattle which were reactors had approximately one tenth the manganese that was found in normal animals. Unfortunately, they did not report the range over which their results were accurate. Cobalt was also determined and found to be lower in the Bang's reacting animals. They do make this statement, that the cobalt results are very undependable and, therefore, cannot be considered as more than indicative. From our own experiments, we believe that the spectrographic method for cobalt which they used is very unreliable and that the results are meaningless. Their conclusion was that animals suffering from brucellosis undergo a loss of manganese, copper, and possibly cobalt from the body. According to the published statement, their analyses were run on pituitary glands, some parts of the brain, and on the blood. No results were reported on the liver, which is the primary storage center for these elements.

With this information that there might be a difference in the manganese, copper, and cobalt content of the reactor and normal animal, the story has been spread until now the elements mentioned are suggested as a cure for brucellosis in cattle. In the publication, several experts, men who had spent many years investigating brucellosis, were quoted. In particular Dr. C. M. Haring, of the University of California, was quoted as believing that susceptibility to Bang's Disease infection is related to nutrition. Therefore, I wrote Dr. Haring and asked him for his frank opinion of the value of minerals and-or nutrition in the treatment or prevention of brucellosis. Dr. Haring's reply was very frank and to the point. He said that he had found a difference in the vitamin A content of the blood of cattle suffering from brucellosis and those that were normal. He pointed out that this difference was that which would be expected from any febrile, that is, fever producing disease, that he had at no time seen any difference in the susceptibility of animals deficient in vitamin A or fed an abundance of vitamin A. It was his opinion that vitamin A had no effect whatever on the susceptibility of cattle to brucellosis infection. While he had done no experimental work with minerals, he saw no reason to believe that they would have any effect. Probably no man in the country has done more work with brucellosis in cattle than Dr. I. Forrest Huddleson, at Michigan State College. In response to my letter to him, he replied that he knew of no evidence that any minerals or vitamins had either a beneficial or deleterious effect upon brucellosis in cattle. Furthermore, he felt that any one using the results of Levis and Emory as indicating that minerals had such an effect, was making a very great assumption, and an unwarranted one at that. Letters were sent to Wisconsin, to Cornell, and to the U. S. D. A. Bureau of Animal Industry and the same answers were received. As of today, it would appear that if there is any difference in the mineral nutrition of cat-

tle suffering from Bang's Disease, it is the type of difference that would be found under any circumstances where a fever was produced.

Certain characteristics of brucellosis make it possible for this type of propaganda to continue. In the first place, the Bang's test is not 100 percent accurate, but it approaches this accuracy as well as any biological test. In addition, certain cattle apparently are able to become non-reactors over a period of time. Some of these may have developed an immunity due to a very light infection. Others may remain carriers, although still giving a negative test. It only takes one animal reacting in this way to provide a testimonial as to the value of treatment, whether it be mineral, drug or vitamin, for brucellosis.

Until a full-fledged experiment with adequate controls is run, under the supervision of someone competent to evaluate the results, it will not be possible to say that manganese, copper and cobalt have any beneficial effect in the treatment of brucellosis, nor is there any evidence at present that they have a bad effect. We have in Florida possibly the most highly mineralized cattle anywhere in the country. There are cattle in this state that have been and are being given an abundant supplement of copper, cobalt, manganese, calcium and phosphorus, and by the token of the propaganda we have heard, they should be positively immune to brucellosis. Unfortunately, when brucellosis is present such cattle seem to have about the usual ratio of this disease.

THE COMPOSITION OF VARIOUS FORAGE CROPS AND FORAGE MATERIALS IN SOUTH FLORIDA WITH PARTICULAR REFERENCE TO CERTAIN VITAMINS AND TRACE ELEMENTS

Dr. W. T. Forsee, Jr.*

The vast Everglades section of South Florida with its peat and muck soils is rapidly developing into a large cattle producing area. The growing of cattle necessitates the production of large amounts of forage of which the Everglades soil is capable. Not only is the soil capable of producing large amounts of pasture and green herbage for feeding its own live stock, but far sighted individuals envision its possibilities as a producer of dried forage for transportation to areas where sufficient local feed is not available. With the advent of such an interest have come numerous problems among which we find the nutrition of the animal consuming the locally grown feeds as discussed by Mr. Kidder in the immediately previous paper. This has led to an investigation of the composition of various forage crops as influenced by soil and fertilizer treatment.

The composition of forage is not a set of fixed constants. The stage of maturity of the plant material influences its composition to a great extent. In general as the stage of maturity increases the protein and ash contents decrease, fats increase slightly, carbohydrates increase and the percent dry matter increases. The proportion of leafy material to stems is another factor governing the composition of a forage, the leafy portions in general being much higher in protein and ash content, slightly higher in fat, lower in carbohydrates and higher in dry matter. These factors that govern the composition and feeding quality of forage can be controlled by proper selection of the time to harvest and by careful harvesting methods that will gather and preserve the forage in a state of highest possible quality. Much work has been done along these lines toward the improvement of forage quality.

In spite of all such efforts to control forage composition and quality, the ultimate feeding value is dependent upon the soil. The influence of soil on plant composition and feeding quality is of a subtle nature but is being recognized more and more. The influence of soils is twofold; first, the native characteristics and natural fertility of the soil and second, the fertilizer treatment and soil management practices. The nutrition of the animal is thus directly dependent upon the soil and the treatment and care we give to this, our most valuable natural resource.

The organic soils of the Everglades have a total nitrogen content of 1.5 to 3.0 percent expressed on a dry weight basis. From such a source of organic material there is a continuous release of available nitrogen. Crops are always growing under high nitrogen conditions except during short intervals when leaching is excessive due to heavy rainfall and weather conditions are unfavorable for ni-

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trification. Forage crops grown on these high nitrogen soils are usually considerably higher in crude protein than those grown on mineral soils. Such a comparison of the crude protein contents of certain forage crops grown on Everglades peat and muck soils with those from other areas is shown in Table I.

TABLE 1 — A Comparison of the Crude Protein Contents of Forage Grown on Everglades Soils with that from Other Forage Producing Areas.

Forage	Protein Content (Percent)	
	Everglades Source*	Other Sources**
Para Grass	11.8	6.2
St. Augustine Grass	13.6	——
Bermuda Grass	13.1	9.0
Kentucky Bluegrass	——	12.8
Alfalfa	26.8	18.0
White Dutch Clover	32.4	21.0
Sweet Potato Vines	19.4	13.7
Peanut Hay	13.1	11.5
Corn, Shelled	12.8	11.2
Average	17.9	12.9

* Oven dry basis.
** Values taken from Feeds and Feeding, 17th Ed. Henry and Morrison, and calculated to an oven dry basis.

The forage crops from the Everglades area averaged 5 percent more in protein than those from other areas. The analyses of pasture grasses listed in Table I are averages of many determinations made on samples collected when the grass was at a good, heavy producing, pasture stage and at different seasons of the year. Most pasture grasses show a higher protein content during the early summer than later in the season even though they may be selected as near as possible at the same stage of maturity. This seasonal variation, however, is not so apparent when the analyses are calculated to a fresh weight basis because of the higher moisture content of the forage during the early part of the season. Grasses frequently attain a protein content as high as 20 percent expressed on the oven dry basis when harvested in the late spring at an early stage of maturity.

The deficiency of Everglades peat and muck soils in copper as evidenced by the tremendous growth stimulation to plants by soil applications of copper sulphate is a well recognized fact (1) (2). The importance of this element in animal nutrition and the desirability of an adequate copper content of all forage already has been discussed in this Symposium. The effect of soil applications of copper sulfate on the copper content of pasture oats is recorded in Table II. These oats were grown on Everglades peat soil that had been under drainage but had remained uncultivated for several years and the soil was thoroughly weathered and well decomposed. There was such a poor growth of oats on the areas receiving no copper that it was

TABLE II — Ascorbic Acid and Copper Analyses of Certain Grasses and Pasture Oats Grown on Everglades Peat Soil.

Forage	Dry Matter (pct. *)	Ascorbic Acid (pct. **)	Copper (ppm. **)
St. Augustine Grass	18.2	0.58	——
Pangola Grass	37.7	0.15	——
Para Grass	17.8	0.62	——
Coastal Bermuda Grass	14.6	0.97	——
Pasture Oats, 50 lbs. | A Cu	17.1	0.92	6.2
Pasture Oats, 25 lbs. | A Cu	20.1	0.72	4.6
Pasture Oats, 12½ lbs. | A Cu	18.1	0.87	3.7
Pasture Oats, no Cu	24.6	0.57	2.2

* Recorded fresh weight basis.
** Calculated on oven dry basis.

difficult to obtain a sample. Copper applications gave a tremendous growth increase. These data indicate that the copper content as well as the yield of forage may be increased by soil applications of copper sulfate. Table II also shows the vitamin C contents of certain pasture grasses and oats grown at the four copper levels. The variations in ascorbic acid content between grass varieties and the variations between the oats grown with and without copper seem considerable. However, the dry matter contents are also quite variable. When the dry matter factor is taken into consideration the differences in ascorbic acid content of the oats grown with and without copper are eliminated and the differences between grass varieties are materially diminished.

During the last few years considerable interest has been manifest in vegetable and other crop waste as a possible source of dehydrated feeds for live stock. In order to have a basis for evaluating crop wastes as potential sources of dehydrated feeds, samples of certain materials have been collected from the fields and processing plants. The samples were quickly dehydrated with controlled temperature under forced draft. Averages of certain of the analyses of these dehydrated products are recorded in Table III. The materials are recorded in the Table on the basis of a 100 gram bulk sample in order that the proportion of leaf to stem material may be observed along with the food elements derived from each. Of particular interest is the high protein, riboflavin and carotene contents of the celery and ramie leaves. Celery waste is now available in large quantities in the Everglades. Furthermore, it offers the added advantage of being available as a steady and uninterrupted source from December to May. Ramie, an expanding industry in the Glades, may be a potential source of material for dehydration during the late spring and summer months. With ramie furnishing a sure source of material from late spring to fall and celery and other crop wastes as an uninterrupted source during the winter and spring, a steady, year-round source of high value material could be available in large quantities for commercial dehydration and production of high quality feed, aside from grasses and numerous other crops.

Ramie is a fiber crop which shows promise of developing to such an extent that an extensive acreage may soon be in produc-

TABLE III — Composition of waste material from certain crops grown on Everglades soils.*

Plant Material	Fresh Wt. (gms**)	Dry Wt. (gms.)	Dry Matter (percent)	Protein (pct.***)	Fiber (pct.***)	Fat (pct.***)	Riboflavin (ppm***)	Carotene (ppm***)
Celery Leaves	36	4.6	13	27.0	3.5	7.0	16.5	313
Carrot Tops Stalks	64	3.8	6	12.5	14.5	3.0	5.0	10
Carrot Tops Leaves	51	10.8	21	28.0	10.0	5.5	14.5	271
Carrot Tops Stems	49	5.8	12	11.0	19.5	5.5	7.5	37
Beans, Canning plant waste	100	9.4	9.4	23.5	13.5	3.0	18.0	25
Ramie Tops Leaves	74	14.8	20	28.5	14.5	8.0	11.0	250
Ramie Tops Stems	26	2.3	8.9	20.0	35.0	3.0	7.0	16

* Analysis made by U.S.D.A. Eastern Regional Research Laboratory, Philadelphia.
** The fresh weight of the leaf and stem portions from a 100 gram bulk sample of the plant material.
*** Oven dry basis.

tion. After separation of the fiber all of the green plant material consisting of leaves and tops is available for processing into feeds and perhaps other valuable by-products. Many analyses have been run on samples of ramie tops with the idea of possible utilization of what promises to be large tonnages of this waste material. The composition relative to certain organic fractions, vitamins and minerals of first crop ramie tops is recorded in Table IV. Note the high protein and ash contents along with a low fiber content and a high potency of certain vitamins.

TABLE IV — Organic and Inorganic Composition of First Crop Ramie Tops Grown on Everglades Peat. *

Protein	23.7	percent
Fat	5.2	percent
Fiber	16.7	percent
N — free Extract	30.3	percent
Ash	13.4	percent
Calcium (Ca)	4.6	percent
Phosphorus (P)	0.24	percent
Carotene	305	ppm.
Vitamin C	210	ppm.
Vitamin B-1	2.6 - 7.2	ppm.
Riboflavin	16.5	ppm.
Niacin	67.1	ppm.
Pantothenic Acid	5.0-26.7	ppm.
Choline	0.19	percent

* These data were calculated to an air dry dasis from analysis of both quick dried and fresh green material. The analytical data from which these calculations were made was furnished by Mr. J. M. Dempsey, Manager Fiber Division, Newport Industries, Inc. The recorded analyses are averages of one to five samples. When the variation between samples was large the high and low limits were listed.

In Table III it may be noted that green ramie tops contain about 15 percent dry leaves and only slightly more than 2 percent stems. The fact that the ratio of leafy to stem material in the dehydrated product is very high may account to a certain extent for the high content of the processed material in terms of valuable feed components.

By proper soil management and a judicious use of fertilizers and soil amendments South Florida can produce tremendous tonnages of forage with a high nutritional value. The area is not only a potential source of forage for its own needs but may ship large amounts to other areas where insufficient locally produced live stock feeds are available.

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THE OCCURRENCE OF MOLYBDENUM IN PASTURE AND FORAGE CROPS OF SOUTH FLORIDA —A LIMITED SURVEY

Mr. T. C. Erwin*

We have seen from the other papers on this morning's program how the Everglades area is favored with certain natural advantages for the production of livestock. These consist largely of the ability of its soils to produce heavy tonnages of forage which are high in protein and vitamins. We have learned how to supply the animals with the required minerals by the use of proper soil treatments and mineral salt mixes. We are learning to insure the availability of forage crops throughout the year by maintaining adequate drainage and selecting grasses that are frost resistant. We also have learned how to control insects and parasites with the help of DDT and phenothiazine.

Is there any reason why the Everglades cannot produce the best beef and the most beef per acre of any place in the world? Are there natural disadvantages of which we have not learned that might offset to some extent the natural advantages? In this paper we will consider the occurrence of the element molybdenum (Mo) in Everglades soils. In doing so we should keep in mind the possible interrelation between high levels of molybdenum and low levels of copper.

In 1935 the Wyoming Agricultural Experiment Station published a bulletin (1) in which they described the symptoms of molybdenum poisoning of cattle. These symptoms were somewhat similar to some of those developed by cattle in the Everglades. To determine if molybdenum could be affecting Everglades cattle, samples of soil and grass were collected and analyzed spectrographically. Molybdenum was found in most of these samples but at relatively low levels with the exception of a few. Because the Wyoming work had shown that cattle have a considerable tolerance for molybdenum, and the failure to consistently find high levels of the element in our grass samples, it was first considered that molybdenum did not play an important role in the cattle industry of the Everglades.

This work caused sufficient interest in the element, however, to point out the need for better methods of analyzing for molybdenum and led to a comprehensive study of methods by M. L. Nichols and Lewis H. Rogers (2). This study supplied the chemical method which is now being used in an expanded survey of molybdenum in Everglades soils and plants.

In 1943 a paper was published on the teart pastures of Somerset (3). This paper showed that the condition known in England as teart pasture was due to a high molybdenum content of soil and plant. The symptoms were described as scouring, bleaching, roughening hair coat, and loss of weight, with death resulting in severe cases.

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Many molybdenum analyses were made to determine the toxic level and to show the variations between different plant varieties and among samples collected at different seasons of the year. The authors reported the danger line to be about 10 ppm of the element on the dry weight basis of the total feed of an animal. They also indicated a variation of tolerance for molybdenum with breed; the dairy breeds showing the least tolerance. They also demonstrated that toxicity could be offset with large doses of copper sulfate.

This 10 ppm level of molybdenum is considerably lower than that of some grass samples collected in the Everglades and strongly suggests further study should be made.

In 1946 J. W. Britton and H. Goss of Davis, California, published a paper (4) on molybdenum poisoning in that state. Their findings substantiated the English reports and showed a remarkable similarity to the condition more recently found in the Everglades. This similarity is largely in the molybdenum content of the soils and of various plants. The major factor which makes the California situation worse is the practice of grazing alfalfa, a plant which is a strong concentrator of the element. A dairy herd has never been successfully maintained in this affected area although many attempts have been made.

The recent survey undertaken to determine the status of molybdenum in the Everglades and reported in part in this paper has included the collection and analysis of over two-hundred soil and plant samples up to the present time. The molybdenum content of the muck soils varies from 0.3 to 6.3 ppm while some sand and marl samples from surrounding areas have only a trace. The lower molybdenum levels in the soil occur at greater distances from Lake Okeechobee or on land which has been cropped for a number of years. It is quite probable that the element is cropped out of the soil by removing plant material which contains appreciable amounts of it. Apparently there is a geographical variation of the molybdenum in the soil as well as one relating to land use history. Both variations are quite complex and make any generalization impossible at this time.

The plant analyses varied from trace of molybdenum to 36 ppm, depending largely on variety and soil characteristics. There are many factors influencing the molybdenum content of a plant. Some of these are: (1) the quantity of the element in the soil; (2) the plant's capacity to absorb it; (3) the reaction (pH) of the soil; and (4) the state of maturity of the plant.

From the data obtained in this limited survey it is quite obvious that there are tremendous differences in the ability of various plants to concentrate molybdenum from the soil. If we have a number of plants growing on soil of similar condition—let us say a muck soil with a molybdenum content of 2 ppm and a pH value between 6 and 7, we might expect the analyses of some common plants to be as follows; St. Augustine, Bermuda, and Para grass, about 2 ppm; pangola grass, rye grass, and oats from 10 to 15 ppm; while white Dutch clover and some other legumes might contain 25 ppm of the element, or more.

It is possible that the molybdenum content of each one of these

plants would be affected differently by changing either the amount of the element in the soil or the reaction (pH) of the soil. Since it was found possible to sample Italian rye grass over an extensive area and under a large variety of soil conditions, we can show how these variable soil factors affect the molybdenum content of this plant. Under any soil reaction conditions encountered if the molybdenum content of the soil was less than 0.5 ppm the content of the rye grass was less than 3 ppm. Where the molybdenum content of the soil was from 1 to 6 ppm the content of the rye grass was greater. In other words, there is a depressing effect on the molybdenum content of Italian rye grass at soil pH's greater than 7.0 or less than 6.0. It is also evident that the molybdenum content of pangola grass is relatively low when the pH of the soil is less than 6.0.

The molybdenum question is of interest in this area because in a number of places the soil conditions are such that when a molybdenum concentrating plant is grown, it may have a molybdenum content of 10 ppm or more, a level which has been considered toxic to cattle. It also is of interest in this connection that in preliminary tests of new grass varieties under study for this area the majority of the more promising ones must be classified as molybdenum concentrating types. The variations among the different varieties are extremely interesting and point the way to a method of avoiding possible trouble from molybdenum toxicity. This will be discussed in more detail by Dr. Bair in a paper that follows.

In June, 1946, some preliminary studies to verify the toxic effect of molybdenum were initiated by drenching several Devon cattle. From this study we have learned that there is considerable individual variation in tolerance to molybdenum and that perhaps the Devon breed is a little more tolerant of the element than some of the other breeds that have been studied. Thus the experiments showed that a young Devon heifer receiving molybdenum equivalent to 15 ppm of the dry weight of the grass she consumed scoured, her hair coat bleached and became rough, and no appreciable gain in weight was made over a six months period. A steer receiving 50 ppm of molybdenum, also by drenching, showed similar symptoms and after nine months of treatment he was thirty pounds lighter than he was when treatment was begun. At the same time another steer receiving molybdenum equivalent to 15 ppm gained ninety pounds; whereas 120 pounds might be considered a normal gain for animals under these conditions and during such a period.

It was also demonstrated, as previously reported, that additional drenches with large quantities of copper sulfate would eliminate the scouring produced by the molybdenum. On the other hand, aluminum sulfate given as a drench did not prevent scouring or weight loss.

It was observed that while grazing a rye grass pasture containing from 10 to 15 ppm molybdenum the Station Devon herd was not affected, but three Guernsey heifers scoured severely under the same conditions and had to be removed to other pastures.

In this survey only one case was found where the total feed of the cattle, for any considerable period of time, would average more than 10 ppm molybdenum on the basis of its dry weight. This

was on a pangola pasture in a high molybdenum area. The situation was soon corrected by applying comparatively large quantities of sulphur to lower the pH of the soil. A few rye grass pastures also were rather high in molybdenum, but these pastures furnished only a part of the total feed for the cattle grazing them. The majority of rye grass samples analyzed contained less than 10 ppm molybdenum. This plant is not considered as strong a concentrator of the element as many other plants tested.

Summary

At present there is no serious danger to cattle because of molybdenum in the Everglades. However, soil conditions are such that if pasture plants are used which have the ability to concentrate the element there is the strong probability of trouble in some areas. The question still to be answered is whether low, non-toxic levels of molybdenum affect the rate of gain of cattle and the economy of the cattle industry.

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THE RELATION OF CALCIUM AND PHOSPHORUS TO ANIMAL NUTRITION

Dr. W. G. Kirk*

I am not a soil specialist but I am deeply interested in the amounts and quality of feed Florida soils produce, and the effect of such feed on the growth and maintenance of livestock. Where there is a lack or loss of thrift in cattle the first thing to be considered always is whether or not it is a mineral deficiency, and this takes you right back to the grass and the mineral content of the soil on which it grew. The absence of a little mineral may make the difference between a thin, restless and unproductive herd and one that grades good in all respects. My talk today deals with the phosphorus and calcium needs of cattle.

Why are phosphorus and calcium necessary to the animal body? Analyzed on a fat-free basis the body of a steer consists of 75 percent water, 20 percent protein and 5 percent ash. Of the ash 1.33 percent is calcium and 0.74 percent phosphorus. Approximately 99 percent of the calcium and 80 percent of the phosphorus are found in the bones and teeth. The remaining 1 percent of calcium is essential for normal blood clotting, the steady working of the heart and normal muscular activity. Phosphorus is part of the protein molecule and therefore a part of every body cell. It plays a vital role in some of the chemical activities of the body, especially the release of energy from feeds. Calcium is normally present in the blood in quantities above 10 mg, and phosphorus from 5 to 9 mg per 100 cc. The amount of phosphorus required depends upon the age and condition of the animal, young, growing and lactating animals needing most. Black and coworkers (1) state that 0.23 percent calcium and 0.13 percent phosphorus on a dry matter basis have been generally accepted as the minimum amounts of these elements required by cattle.

There is an extremely close relationship between calcium, phosphorus and vitamin D. The optimum Ca:P ratio in the feed appears to be between 2:1 and 1:2, but with the abundant Florida sunshine which activates ergosterol, the precursor of vitamin D, as wide a ratio as 6:1 may be satisfactory. Vitamin D causes a more efficient utilization of the calcium and phosphorus of the feed and does much to control the mineral balance even when the calcium level is excessively high and the phosphorus below the minimum requirement, as is the case with most native forage.

Calcium is present in relatively large amounts in the stalks of plants and low in the seeds, while the reverse is true for phosphorus, the seeds containing most. A high calcium and low phosphorus content may result in the formation of a calcium phosphate compound that cannot be assimilated by the cow. Young grasses are

(1) Black, W. H., L. M. Tash, J. M. Jones and R. J. Kleberg, Jr. Effects of phosphorus supplements on cattle grazing on range deficient in this mineral. U. S. D. A. Tech. Bul. 856, 1943.

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high in protein and consequently in phosphorus, but as the forage matures the amount of both protein and phosphorus decrease and the grass becomes unpalatable in consequence. For all these reasons Florida cattle, getting most of their feed by grazing, are likely to be inadequately supplied with phosphorus and to show all the characteristics of such a deficiency.

The most apparent symptom of phosphorous deficiency is bone chewing. However, an affected animal will try to eat shells, wood, hair, feathers, soil or even flesh with equal appetite. Unthriftiness is one of the outstanding signs. There is a developing stiffness of the joints, whence the name stiffs, and as mineral matter is withdrawn from the skeleton to supply other body needs the bones weaken to the extent that fractures are common. These painful conditions make grazing difficult or impossible and death from starvation may ultimately ensue. Other evidences of aphosphorosis are failure to breed and low milk production; weak and stunted calves; small and slow maturing animals; and a greater susceptibility to disease. Dry cows that are in good flesh because their need for phosphorus is low may be unable to survive the strain of calving if bred.

What are the phosphorus requirements of range cattle? In the dry ration the minimum needs will be met by 0.13 percent of phosphorus. Black, Knapp, and Douglas (2) state that from 0.2 to 0.3 percent will give nearly optimum quantities, the amount being greater for growing and breeding cattle than for fattening animals. This means that on a dry matter basis an 800 pound cow eating 14 pounds daily would have a yearly minimum phosphorus requirement of 6.64 pounds, and a maximum need almost twice this amount.

Sixteen samples of wire grass obtained at regular intervals from February, 1945 to October, 1946, from an unburned area at the Range Cattle Station contained on the average 0.08 percent of phosphorus, the variation being from 0.05 to 0.11 percent. Cows getting all their feed from such a range got 4.09 pounds of phosphorus, or three-fifths the minimum requirement. Wire grass samples from an area burned in February, 1945, averaged 0.888 percent phosphorus, this providing 4.49 pounds yearly. Unfertilized carpet and Bahia grass contained 0.116 and 0.104 percent phosphorus respectively, while the content of fertilized, improved pastures during the growing season, March to October, was from 0.19 to 0.27 percent, sufficient to meet the requirements. Steers on the improved pastures, however, consumed an average of 1 pound of bonemeal every 25 days. This indicates that in late fall and early winter these pastures would not provide enough phosphorus to meet the demands of the steer, much less those of a producing cow.

The calcium content of wire grass from the unburned plot averaged 0.58 percent, which gave a Ca:P of 7.25:1, while that of the burned plot was 6.36:1.

Since 1942 several mineral mixtures have been used at the Range Cattle Station and various changes made to increase palat-

(2) Black, W. H., Bradford Knapp and J. R. Douglas. Nutritional requirements of beef and dual-purpose cattle. U. S. D. A. Yearbook of Agriculture, Food & Life, 519-543, 1939.

ability and consumption. Each time bone chewing was observed the formula was altered in an effort to get a higher intake of phosphorus. The mixture now being used is as follows:

Steamed bonemeal	26.00	percent
Defluorinated superphosphate	26.00	percent
Common salt	33.89	percent
Red oxide of iron	3.39	percent
Copper sulfate	0.68	percent
Cobalt chloride	0.04	percent
Blackstrap molasses	5.00	percent
Cottonseed, soybean or peanut oilmeal	5.00	percent

Defluorinated superphosphate has been used to replace one-half the bonemeal because it is more readily available and less expensive. Molasses and high protein oilmeal were added for palatability. The salt prevents spoilage of bonemeal in wet weather and the combination of salt and molasses draws sufficient moisture to reduce loss from blowing.

The average mineral consumption by cows at the Station for the year beginning July 1, 1942, was 20.24 pounds. This amount was not believed to be sufficient to supply the phosphorus lacking in the range forage and in August, 1944, 3 cattle were observed chewing bones. Blood tests made in September showed that the inorganic phosphorus of their blood was 3.25, 3.04 and 4.20 mg per 100 cc respectively, definitely within the deficient range.

From 30 to 40 blood samples from cows on unimproved range were taken in December, 1944, January, April, August and October, 1945. In December 4 cows had less than 4 mg of phosphorus per 100 cc of blood, 5 in January, 6 in April, 16 in August and none in October. August is the month when mineral consumption makes a noticeable rise over the April-July period. The estimated intake for these 12 months varied from 26 to 46 pounds, the difference being due to the supplemental feeds given during wintering trials.

Five groups of cows have been kept on unimproved range since 1943. These cows run together from April to November at which time they are separated into their various groups for winter feeding tests. The average mineral consumption for each of the 5 groups is given in the following table:

Average Total Mineral Mixture Consumed Annually by Mature Cows under Different Pasture Conditions

	Total Salt Mixture Consumed Annually, per Cow (lbs.)				
Pasture Condition	1942-43	1943-44	1944-45	1945-46	Average
Unburned Range	——	——	46.29	75.67	60.98
Burned Range	20.24	25.43	33.71	62.50	40.55
Burned plus molasses	——	17.48	28.92	54.71	33.70
Burned plus fresh sugarcane	——	18.32	26.40	52.87	32.53
Burned plus cottonseed pellets	——	17.93	27.55	45.21	30.23
One-fourth pasture improved and fertilized plus green oats in winter	——	——	12.40	11.03	11.72*

*Average for 2 years other lots for 3 years.

It is seen from the table that cows on native, unburned pasture consumed more than twice as much mineral as those on burned pasture plus cottonseed pellets, and over 5 times as much as those on partially improved pasture plus limited quantities of green oats. These data do not take into consideration the mineral eaten by the calves. At 3 months of age calves have been observed around the mineral boxes eating with relish and when weaned at 7 months they regularly visit the boxes in their new pastures.

Cattle eating 75.76 pounds of mineral mixture obtained 5.30 pounds of phosphorus which, added to the quantitiy in the forage, made a total of 9.39 pounds. With an estimated minimum requirement of 6.64 pounds there was an excess of 2.75 pounds. The yearly mineral intake has been increasing ever since the first record obtained in 1942-43 and, during the current year, will average over 100 pounds per animal for some groups.

The quality of the pasture is indicated in the following table showing the average mineral consumption by months:

Average Monthly Consumption of Mineral Mixtures by Mature Cows under Different Pasture Conditions

Month	Salt Mixture Consumed per Individual (lbs.)				
	Av. for All 5 Groups*	Condition or Treatment of Pasture			
		Unburned Range**	Burned Range		Part. Imp.**
			Without Suppl.*	With Suppl.***	
July	1.49	——	——	——	1.38
August	2.33	——	——	——	0.83
September	2.56	——	——	——	1.50
October	3.35	——	——	——	1.87
November	——	5.26	4.57	3.76	2.03
December	——	9.89	8.50	4.76	1.50
January	——	11.45	5.77	3.61	0.87
February	——	8.52	2.21	2.08	0.51
March	——	6.29	3.27	1.92	0.31
April	2.37	——	——	——	0.26
May	2.06	——	——	——	0.25
June	2.17	——	——	——	0.42

* Average for 3 years, summer months only.
** Average for 2 years.
*** Average for 3 groups fed either molasses, fresh sugarcane or cottonseed pellets.

The data in the above tables answer a few of the questions about how much mineral cattle on Florida ranges will eat and bring out some of the factors that influence consumption. The surprise has been that cattle may eat as much as 100 pounds of mineral a year. This widens the field of inquiry. Do cattle require this much or have they simply developed a mineral habit? Do some cattle eat 50 pounds while others eat 150? Is it economical to supply this amount of mineral, or is there some better way to do so, such as through the grass or mixed with other feed? Does the high calcium content of range forage play any part in the mineral picture? Are temperature and rainfall significant factors? The main conclusion is that more detailed studies are necessary on the inter-relationship of soil, forage, and cattle and, perhaps climate.

The increased mineral intake by animals at the Range Cattle Station has been accompanied by an increase in cattle weights,

greater calf crop and heavier calves at weaning. No bone abnormalities nor nutritional disturbances have been observed during the past 18 months.

The importance of giving cattle access to a good mineral mixture at all times cannot be stressed too strongly.

A PASTURE AND FORAGE CROPS PROGRAM FOR SOUTH FLORIDA

Dr. Roy A. Bair*

A man of discernment who had no experience in agricultural work came to me a while back because he had observed something which aroused his curiosity. For several years he had been cutting back a shrub in his yard, and in the course of a few years, he had removed hundreds of pounds of material. Yet there was no hole in the ground! Where had the bulk of the tree come from? The answer is, of course, "From the air." If you should place one hundred pounds of freshly cut grass in a high-temperature oven, less than two pounds of ash would result. The ash represents the soil's contribution to the plant.

Another way of looking at this situation is that better than 98 percent of a grower's problems are solved for him in Florida, for he has an abundant supply of air and water. This Society is particularly concerned with the problems represented by the two percent contributed by the soil.

Certain plants have already solved most of the problems. Look on any type of soil in Florida and you will see green plants any time during the year. Unfortunately, these plants are often worthless agriculturally or esthetically! But they are adapted to all sorts of soils and climatic extremes; as drought, heat, cold, excessive water, low fertility. Consequently, in setting up an experimental program to find pasture plants adapted to the various soils of Florida, we chose to believe that, somewhere among the quarter of a million varieties of known plants in the world there must be some already "made to order" for each set of local conditions. Rather than rely on the slow, expensive and unpredictable results of plant breeding, we have felt that the time and talents of our limited personnel could be used to the best advantage in undertaking to test as many varieties as possible from as many parts of the world as possible and on as many South Florida soil types as possible.

The very preliminary reports, in tabular form, (tables I and II), which have been placed in your hands today represent the results of tests of nearly one thousand accessions during the last three years: legumes, grasses, oats, wheat, barley, rice. Mr. Charles C. Seale has varieties of all small grains now growing at the Everglades Experiment Station from seed produced at the Station last year. From introductory nurseries at the Everglades Station containing 300 grasses and 175 legumes, Mr. Leonard Payne has carried the most promising varieties to eleven locations on as many different agriculturally important types of soil in South Florida. In each locality representative land has been chosen by ourselves and the local County Agricultural Agent on property owned by a good cooperator.

*Agronomist, Everglades Experiment Station, Belle Glade.

The locations of these experimental plots are as follows:

Type soil	pH	Location	Cooperator
Sandy muck	5.6	Moore Haven	Woburn Chemical Co.
"Acid" muck	4.5	Brighton	Durrance Ranch
Sandy prairie	6.6	Okeechobee	Clifford R. Boyles
"Acid" sand	4.5	Okeechobee	Edwards Cattle Company
"Sweet" sand	6.5	Fellsmere	Circle F Ranch
"Hammock" sand	6.5	Vero Beach	W. E. Sexton
Flatwoods sand	5.5	Boynton	O. W. Winchester
High, dry marl	8.0	Uleta	J. Arthur Pancoast
Low, wet marl	8.0	South Miami	Charles T. Fuchs
Davie sand	6.5	Hialeah	John G. DuPuis, Jr.
Dry ridge sand	4.5	Opalocka	Royal Dairies, Inc.

The experimental program with pasture grasses and legumes involves three cycles. In the preliminary phase, all varieties which we can borrow, beg or steal from any place in the world are planted in 4x10 foot plots at Everglades Experimental Station where they are first observed for characteristics related to their potential usefulness: rate of growth, density, resistance to flooding, drought, heat, frost and cold, insect pests and plant diseases. The more promising varieties are then established at the various locations described for tests on the several important types of South Florida soils. The very best strains are also planted in acre pastures where they are observed for ability to put gains on cattle and to thrive in spite of close grazing, trampling and the resultant soil compaction. At this stage, cattlemen are encouraged to test the most promising varieties in small pastures concurrently with our own preliminary grazing trials. All varietal trials in Cycle I are conducted under conditions of optimum fertility since our objective, at this stage, is to find strains adapted to South Florida climate and soils where fertility is not a limiting factor.

In Cycle II the emphasis centers on the minimal conditions necessary for the establishment of nutritious pastures on definite soil situations. In this phase the best and most economical methods are investigated for planting and establishment. Mr. Charles C. Seale is responsible for testing the efficiency of 2, 4-D and various other chemicals for weed control; and we are just now much pleased with the performance of a reel-type, gang mower in controlling weeds while newly planted pastures are becoming established. Now, we are also concerned with compatability studies; which grasses and legumes will grow together and not smother the other. In such a combination, the legume will provide more forage than grass alone, and will also produce more grass because of the nitrogen the legume can furnish to the grass. This legume-grass relationship is of great importance because it will help materially in reducing fertilizer costs for the rancher and dairyman.

Fertility studies, barely begun as yet, will occupy an important place in this second cycle of pasture research. From an economic standpoint, it is vital to know just how little fertilizer will permit pasture establishment and provide nutritious grazing for the cattle. This double standard for determining fertilizer requirement cannot

be overemphasized. All recent evidence from the research in animal nutrition is that, with many pastures, the fertility level may be high enough to promote excellent grass growth, but the mineral content of that forage may be so low, in terms of the animal's needs, that the cow is actually starving. The testimony of the cow must provide us with our ultimate yardstick in assaying the value of any pasture plant or fertility program. The whole objective of our research program is to produce more and better beef or milk, healthier and more contented cows, if you please.

Before fertilizer recommendations can be made for a pasture, it is clearly important to learn what nutrients are already present, if a cattleman is not to waste a part of his money; and we Agronomists would be working blindly if means were not available for evaluating residual soil fertility. The cooperation of a well staffed, completely equipped soils laboratory is therefore requisite for an intelligent fertility program. Furthermore, since different pasture plants vary widely in their ability to concentrate nutrient minerals or synthesize proteins, for example, the importance of laboratory facilities for plant analyses is just as obvious. We must know what grass to recommend, knowing what part of the fertilizer actually gets into the plant and so becomes available to the cow.

Unfortunately, we have been recently told by Mr. Erwin that the toxic element, molybdenum, is present in potentially dangerous concentrations in a limited area near Lake Okeechobee. While the Soils Department at the Everglades Station lack proper equipment at present for properly evaluating the extent of this condition in the soil, the techniques for the determination of molybdenum in plant tissues are much simpler. As Mr. Erwin has told us today, his discovery that certain varieties of plants are concentrators of molybdenum has enabled him to establish approximately the areas in which this element may be present in objectionable quantities.

Although most of the 300 new grasses and legumes in our experimental nurseries were undamaged by the February freeze, some of the most promising pasture possibilities may have to be discarded in recommendations for pasture in the immediate vicinity of the Lake, for they appear to concentrate molybdenum in dangerous quantities. A soils test for this element should precede our recommendations for varieties to be planted on any Everglades muck.

The following determinations were made by Mr. Erwin for a group of our most frost resistant, vigorous grasses. A concentration of 10 parts per million (ppm.) or more is considered to be toxic to cattle. Varieties of wheat were uniformly low, and the barleys were only a little higher in their molybdenum content. Our most promising oat, C.I. 4076 was very low, while the common Florida variety, Fulghum, contained 13.0 ppm.

	Molybdenum (Mo.) ppm.*
Wheat varieties	1.6- 2.9
Barley varieties	3.9- 5.0
Oats varieties	3.3-13.0
Reed canarygrass	1.7
Brome	2.2

	Molybdenum (Mo.) ppm.*
Italian ryegrass	4.0
Rescue	5.0
Kentucky-31 fescue	7.7
Orchard	8.0
Phalaris angusta	8.3
Dallis	9.3
Tall meadow fescue	10.7
Creeping red fescue	10.5
Abruzzi rye	12.0
Tall oatgrass	13.3
English bluegrass	15.0
Colonial bent	24.0

*Parts per million on oven dry basis.

Thus it would appear that we must select for inability to concentrate this element, as well as for adaption to the many climatic and soils factors peculiar to South Florida. There is some evidence that fertilizer balance and quantity may be utilized to suppress the uptake of this mineral by plant roots. The possibility has been suggested, in the preceding paper, of cropping out molybdenum by planting known concentrators and then removing the forage.

For the third and final cycle in the development of a pasture program we hope to persuade owners of large herds of dairy and beef cattle to work with us in cooperative trials on a large scale, utilizing the information gained in Cycles I and II to make the conclusive tests of pasture varieties, fertilizer and management practices with various breeds. The cow must be the ultimate judge of our research program, in terms of milk and of beef.

PROMISING PASTURE PLANTS FOR SOUTH FLORIDA, 1946-47

LEGUMES		MUCK	SAND				MARL
Common name	Scientific name	& peat	Davie	Dry, ridge	Flat-woods	Dry	Wet
Arizona Chilean alfalfa	Medicago sativa	++		++		+:	
Argentine "	do.	++	+	+			+
Buffalo "	do.	++		+			
Grimm "	do.	++				+:	+
Hairy Peruvian "	do.	++		++		+:	+
Kan. common "	do.	++	+				
Black medic clover	Medicago lupulina	+		+		+:	+
Calif. bur "	M. hispida	++	++	++		+:	
Common crimson "	Trifolium incarnatum	++				+:	+
Dixie " "	do.	+					+
La. red "	T. pratense	+++	+			+:	+
Cumberland red "	do.	+++	+				
Midland red "	do.	+++	+				
Emerald sweet "	Melilotus alba	++	++			+:	+
Eng. wild white"	Trifolium repens	+		+			+
La. white Dutch"	do.	+++		+			+
Ladino "	T. repens latum	+++		+			
Manganese "	Medicago arabica	+		+			
Hubam "	Melilotus alba	+++	+	+++		+:	++
Yel. blossom sweet clover	M. officinalis	+	++	++		++:	++
White blossom sweet clover	M. alba	++	++	+			
Sourclover	M. indica	++	++			+:	
Subterranean "	Trifolium subterraneum	+	+				
F.P.I. 90753-A-35	Melilotus dentata	++					
Creeping beggarweed	Desmodium obtusum		++	+			
Crotalaria	Crotalaria intermedia	+	+				
"	C. striata	+	++			++:	
Hairy indigo	Indigofera hirsuta		++			+:	
Birdsfoot trefoil	Lotus corniculatus arvensis	++		++			
Narrowleaf "	L. corniculatus tenuifolius	+	+				
Hairy lotus	L. uliginosus villosus	+	+	+			+
Yel. sweet lupine	Lupinus luteus			++			
Sweet speckled "	do.			++			
Singletary pea	Lathyrus hirsuta	+	+				+
Dixie wonder pea	Pisum arvense	+	+				+
Papago pea	do.	+	+				
Common vetch	Vicia sativa	+	++	+			
Purple "	V. atropurpurea	+					
Woolly-pod "	V. dasycarpa	+	++				
Augusta "	V. angustifolia	+	+				
Big flower "	V. grandiflora	+		+			

Note: + = good; ++ = very good ; +++ = excellent adaptation.

PROMISING PASTURE PLANTS FOR SOUTH FLORIDA, 1946-47

PERENNIAL GRASSES		Muck & peat	Sand			Marl	
Common name	Scientific name		Davie	Dry, ridge	Flat-woods	Dry	Wet
St. Augustine	Stenotaphrum secundatum	++	+	++		++	+
Pangola	Digitaria decumbens	++	++	+++	++	+	+
Coastal Bermuda	Cynodon dactylon	++	+	+	+		+
Tifton 99 "	" "	+	+	++	++		++
Torpedo	Panicum repens	+	++		++		
Tall fescue	Festuca elatior arundinacea	++	++			++	++
Ky.31 "	do.	++	++			++	++
Meadow fescue	F. elatior			+		++	
English bluegrass	F. pratensis	++				+	
Red fescue	F. rubra	+	+	+		+	+
Creeping red fescue	F. "	+	++	+			
Duraturf "	F. "	+					
Tall oatgrass	Arrhenatherum elatius	++					
Reed canary	Phalaris arundinacea	++	+			++	
Harding	P. tuberosa arundinacea	++				++	
Texas bluegrass	Poa arachnifera	+				+	
Kentucky "	P. pratensis	++				++	
Orchard	Dactylis glomerata	++	+	+		+	+
Pensacola Bahia	Paspalum notatum	+	+		+		+
Wallace "	do.		+				+
Dallis	P. dilatatum	+		+			
Cogon	Imperata cylindrica		+			+	
Smooth brome	Bromus inermis	+				++	
Weeping lovegrass	Eragrostis curvula	++	+		+	+	
Giant panic	Panicum antidotale	+			+	++	+
Rhodes	Chloris gayana	+	+			+	+
Common Guinea	Panicum maximum	++			+		+
Kreamer Is. "	do.	++		+			++
ANNUAL OR BIENNIAL GRASSES							
Abruzzi rye	Secale cereale	+	++	++	++	++	++
"Fla. timothy"	Phalaris angusta	+++	++		+		
Canary	P. canariensis				+	++	
Lelina-15 oats	Avena sativa		+				
C.I. 4076 "	do.	++					
C.I. 4053 "	do.		+				
Fla. 167 "	do.	+					++
Tenn. winter barley	Hordeum vulgare						+
C.I. 6120 "	do.		+	+			
Hooded 16 "	do.		+				
Italian ryegrass	Lolium multiflorum	+				++	
Rescue	Bromus catharticus						

SYMPOSIUM II: IMPORTANCE OF WATER CONSERVATION TO THE DEVELOPMENT OF SOUTH FLORIDA

Hotel Pennsylvania, West Palm Beach, April 4, 1947; 2:00 P.M.

REVIEW OF PROGRESS SINCE 1943 IN THE MANAGEMENT AND OPERATION OF THE EVERGLADES DRAINAGE DISTRICT

Mr. J. E. Beardsley*

The subject reads "Review of Progress Since 1943 in the Management and Operation of the Everglades Drainage District," but I am going to begin with a little past history, for the benefit of those who have not heard its past history, and then review the progress made by the District. In 1931 Everglades Drainage District went bankrupt. It was unable to meet its bond and debt service commitments and that condition continued to exist until 1941, at which time there was outstanding a debt of very nearly 17 million dollars and between 10 and 12 million dollars of delinquent taxes uncollected against the lands in the District. I make the point about delinquent taxes because the recent renaissance of development in the 'Glades can be traced to the removal from the lands of the lien which existed in 1941 for those delinquent taxes. It is hard to sell a developer or farmer on the improvement of a piece of property which he acquires with a tax load of $40, $50 or $60 an acre, without any idea as to how the tax lien can be liquidated. At that time, Hon. Spessard L. Holland, in following out his campaign promises, undertook to do something about the situation in the Everglades. He obtained support of some bond people who acted as financiers, with the net result that the District wiped out that 17 million dollars of obligations with a loan from Reconstruction Finance Corporation of $5,660,000 committed. In the 1941 Legislative Act there was a simple provision for the compromise of delinquent taxes, resulting in hundreds of thousands of dollars coming to the District almost immediately. You will not hold me remiss in reminding all of you who have an interest in the Glades that we probably never will be able to pay the debt of gratitude which we ought to feel to Spessard Holland for his interest in the problem. It may have had its political aspects as far as he was concerned, but his genuine interest cannot be questioned. It is possible that we are saved today by that interest.

In 1944 the District was in such improved financial condition with respect to its debt service obligations to Reconstruction Finance Corporation, that with the help of the Ranson-Davidson Bond Company, Mark Tennant, who is in the audience, then Chairman of the Everglades Drainage Board; Lew Hall, the Attorney and Turner

*Vice Chairman, Board of Commissioners, Everglades Drainage District, Clewiston, Fla.

Wallis, the Board's Engineer, were able to consummate a refunding of the District's obligations and there was enough cash on hand so that new bonds then issued and handled by Ranson-Davidson, Inc., were in the amount of only $4,500,000. This was in October, 1944. The district at that time had an additional sum in cash which it was not deemed expedient to put into the transaction since it was felt that some reserve should be available.

The above shows us the debt service side of the financial affairs of the District which has largely concerned us, because through the liquidation of the outstanding debt of 1941 and the elimination of the load of delinquent taxes, we find ourselves today in such remarkably sound financial condition. Thus, on last Tuesday the Board not only met the $75,000 of principal which fell due on that date and the more than $70,000 due as interest at the same time, but paid off bonds callable in the amount of $690,000; and then after all this payment, it found that it still had $517,000 in the bank plus a reserve fund in United States Government bonds of $500,000. It has purchased $66,000 of its own bonds, which are callable in 1950, so that those have been in effect liquidated. It has in that $517,000 cash, $185,000 which it is proposed by court action, and perhaps by legislation, to transfer into a maintenance and operations fund as set forth in the bond measure in 1944. In an excess of caution, the $185,000, since 1944, has been kept in the debt service fund. If there should be any questions as to the advisability of that proposed plan, it is now called to your attention.

If the District were to liquidate today, the initial obligation to R. F. C. of $5,660,000 would have been cut in less than six years to $2,700,000. I don't know whether any municipality or quasi-public corporation in Florida, or anywhere else in the United States, can match that record. The credit is due, let me impress upon you, not to the members of the Everglades Drainage District Board, not to their attorney, not to their Engineer, but to those tough customers in the Everglades anywhere west of the coastal towns who have seen the wisdom of footing the bill and have footed it and who are determined that taxes shall be kept up to pay off that bonded debt, I hope in 1955, so that the 30-year term bonds as issued will have been completely liquidated in 14 years. Bonds weren't issued until 1944. That is the picture of the debt service side of the District's progress today—the fact that its total outstanding obligations have actually been cut in half. That, of course, is not the entire picture of the District's operations.

People here pay an acreage tax on the better grades of lands of $0.80 to $1.50 per acre and are perfectly willing to pay that tax for a short period of time because they fully appreciate the fact that the debt is a sort of dead horse which has to be hauled off and buried, even though the money was spent 20, 30 or 40 years ago and their lands must stand it. This situation might exist for a couple of years and be satisfactory to the landowner but there comes a time when he says "I want some service for the taxes I am paying. I want to put my land in cultivation, know that it can be kept in cultivation and that for the payment of my $1.50 an acre that E. D. D. will provide me with the facilities for moving water." That shows one side

of the progress picture, reminding me of a similar occasion in Belle Glade when I stood before the Soil Science Society discussing Everglades matters and made this remark: "We have outlined about all the work we can do in the District but no one has provided the means for furnishing the money for actual physical work." E. D. D. assesses on the lands throughout the District a tax of 1-2 mill ad valorem for administration. I might as well be frank about it. Some attorneys hold that the law confines the use of that fund to what we automatically consider administration purposes—salaries, office work, etc.,—but the Board, because the law states "care for the District generally" has taken the liberty of using out of that Administration fund such monies as it felt safe in subtracting for such maintenance and operation expenses as we could afford. That 1-2 mill tax realizes $70,000 a year for collecting $550,000 acreage tax every year and covering 4 1-2 million acres in parts of 11 counties in South Florida. I cite this because it is apparent that the nominal expenses of the pure administration of such a District, fees to Tax Collectors and Tax Assessors who handle our tax matters, Attorney's salary, Engineer's salary, Treasurer's salary and routine office expenses, use up a large share of that $70,000. I think there is a solution to the problem and later on in the program Ralph Blank will discuss legislation. How throughly he will go into the Everglades part of it, I do not know. There is a need for the District not solely to maintain its function as a tax collection agency but to provide funds for maintenance and operation.

Concerning legislation, I would like to make this remark. It is surprising to me that such a District in its present state of active functioning should continue to operate on the basis of a Legislative Act of 1931 which was prepared by the late W. L. Evans. It is really amazing that there virtually has been no change. The District has secured no legislation except for the Refund Act of 1941 which was necessary to have the District liquidate its bonded debt. There is proposed this year a Bill which we hope will remedy some of the difficulties which are apparent. But for 16 years, for the 6 active years, statutory provisions made in 1931 remain effective. We all recognize these provisions are going to prove inadequate in many instances to our present conception of the needs in the District. That conception has changed considerably through the years.

The largest share of our new concept of the needs and the possibilities of the District should be credited to Dr. Allison, who has preached for many, many years the need for conserving the water and, in conserving the water, the land. The rest of this program this afternoon covers the vital points of that. This is all part of a continuing process that has yet to be sold, not to the general average of such as you who sit here, but to the fellow with his kahki shirt and breeches and his boots who is out in the 'Glades making a living from a piece of land he holds. He has not been sold on it. The program now is beginning to be appreciated and the need for an overall program recognized. We have made progress.

The District's reclamation plans for the future will be outlined later by Lamar Johnson, the Board's Engineer. In these there are delineated for development extensive areas contiguous to existing

arterial canals and to other canals still to be dug. They will include the setting up of these sections in such a way that a direct tax can be charged against the land for the maintenance of the facilities which service the area. The upper Hillsboro Canal area, for instance, from Belle Glade to Brown Farm will constitute one of those maintenance areas: thus, land which derives direct service—I started to say benefit, but the District is not set up as a benefit organization —will bear the direct cost of necessary improvements and their operation.

The most forward looking accomplishment of the District during recent years is the definite establishment of three so-called conservation areas. It is proposed to put an area north of Hillsboro Canal, running not quite to the Cross Canal, into a conservation area in which water will be pooled and, in the not too distant future, to turn that area over to the Federal Wildlife Service to care for, the District reserving water control rights. Much of that land where fires have been worst will serve as a storage basin for water and, having been re-watered, will not catch fire. Deerfield to Fort Lauderdale west, and from Hillsboro to North New River Canal, constitutes a second area. Another area is in Dade County, running from Broward County Line to Tamiami Trail and west to the new Everglades National Park.

This approach to water conservation is a new thought and a decidedly forward looking step because it serves not only the purpose of flooding and thus providing a source of water during the winter, but of preventing fires in the lower 'Glades which always has been highly subject to that hazard. It will also do a number of other things besides protect and promote wild life activities and possibly ease up winter temperatures in this section. Mr. Parker will touch on municipal water supply. Everglades Drainage District holds no brief for the cities of Miami or Miami Beach in the solution of their water supply problem. It makes no difference to Everglades Drainage District that Miami Beach gets it water, or from where, but if these conservation areas can be set up to serve the other purposes of the District, they can't help aiding all of the east coast cities in a problem which is causing them increasing uneasiness—the source of domestic water.

Somewhere on the program this afternoon Mr. J. W. Milligan of the U. S. Weather Bureau and stationed at the Everglades Experiment Station will talk of climate in the 'Glades. How many realize that water over the lower 'Glades would appreciably change the climate on the lower east coast and in changing that climate be of inestimable benefit to the farmers in the coastal area. Our job is to take care of agricultural interests.

To get down to brass tacks of every day operation, one more comment: If you drive along the roads to the Everglades today, and some of you will this evening or tomorrow morning for the Everglades Station program tomorrow, you will see a surprising thing—open water in the canal. For years those canals had been green gardens except when frosted during certain seasons; there were marvelous beds of flowers. However, these immense mats of water hyacinths were most restrictive to the flow of water. Mr. B. S.Clay-

ton has estimated that the ordinary flow of our canals has been reduced by as much as 50 per cent by them. The district, in cooperation with the Everglades Experiment Station, has a 2, 4-D hyacinth spraying program which we hope you will see tomorrow. The evidence of its success can be seen, if you look not only at the open water but at water marks on the banks. The high water mark, you will find, is two to three feet higher than the water level of today. There has been no such movement of water in 20 years.

An immediate project has been carried through, costing some money. That money has to come from somewhere. If you are taxpayers and have some political influence in Tallahassee, it might be useful. We have a tremendous program for the future. Our Engineers recently showed me a reclamation plan for limited areas which will cost 13 million dollars. Costs for lands to be benefitted would amount to from $21.00 to $23.00 per acre; but many a grower has lost five times that amount in the last two months. The cost is actually negligible if the program can be thoroughly sold and effectively carried through. We propose to try to do it.

SOME SURFACE — WATER RELATIONSHIPS IN SOUTH FLORIDA

Mr. Dean B. Bogart*

The U. S. Geological Survey started water investigations in south Florida as far back as 1913 when a few miscellaneous discharge measurements were made. In 1930 and 1931 several gaging stations were established in the lower Kissimmee River basin and around Lake Okeechobee. This work was in cooperation with the Okeechobee Flood Control District and its purpose was to study the characteristics of the lake, but intensive studies in the Everglades proper and along the coast were not started until 1939. It was then that the City of Miami experienced a real threat to its municipal water supply owing to contamination by salty water. Some of the supply wells became unusable and were pumped to waste for lengthy periods.

As a result of the Miami situation, the U. S. Geological Survey was requested to make water investigations in cooperation with Miami, Miami Beach, Dade County, and Coral Gables. The studies included surface waters, ground waters, and the geology of the area. This paper discusses some of the surface-water phases of the investigations.

The studies for the Miami area had two principal purposes: (1) to observe and measure the extent of the intruding salty water, with a view to protecting the existing fresh water; (2) to make a water inventory and explore other possible sources of municipal supply. The first purpose required detailed studies in the immediate Miami area. The second purpose necessitated investigations as far afield as Lake Okeechobee and, in general, the whole Everglades area was covered**. In 1943, at the end of the initial investigation, the volume of work with respect to the Miami problem was reduced as it was felt that certain basic relationships had been defined and established***. Therefore, a smaller, continuing program was set up in the Miami area.

Although most of the studies in the Everglades had been carried on for the purpose of locating municipal supplies, they were also applicable to other water problems such as drainage, irrigation, conservation, development, wildlife, and recreation. It is axiomatic that much of the value of water-resources work lies in its continuity, and as this was recognized by the Everglades Drainage District, in 1943 financial cooperation was established with the U. S. Geological Survey with the result that the Everglades investigations were continued and new work was undertaken. The District appreciated the need for and the value of such records and is now a major

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** Ferguson, G. E. The plan and progress of recent surface-water studies in the Everglades. Soil Sci. Soc. of Florida, Proceedings, vol. IV-A, pp. 77-85, 1942.

*** Ferguson, G. E. Summary of three years of surface-water studies in the Everglades. Soil Sci. Soc. of Florida, Proceedings, vol. V-A, pp. 18-23, 1943.

cooperator. Since 1943, the Survey has supplied the basic data necessary to the effective development of a large drainage district, including information for planning, improvement, and design. Later on, Dade County, under the impetus of its Water Control Act, became more interested in surface-water studies and is also a major cooperator. These several authorities realize that water studies made for them individually are occasionally coextensive, and they have given the Survey a free hand in determining where observations should be made. They are aware that water events in the Everglades are far-reaching and that studies must be coordinated for best results.

Gaging stations, where records of stage and discharge are maintained, were established at many key locations in the Everglades and coastal area. Special studies covering in great detail a part of a canal, an entire canal, or a group of canals were made. Tidal hydraulics were studied and special procedures developed for obtaining discharge data under the difficult conditions imposed by tidal variations. Because of the lack of weather information four meteorological stations for measuring rainfall, evaporation, and temperature were established in cooperation with the U. S. Weather Bureau. Eight stations were established for measuring rainfall only.

It may properly be asked, of what value are all these studies and accumulations of information? What practical application have they? These questions may be answered briefly by stating that studies of surface water include: (1) stage, or the elevation of the water; (2) discharge, or the quantity of the water flowing; (3) quality, or the chemical composition of water, which is closely associated with the other two items. These phases of water research cover the basic problems, the solutions of which may be found from the surface-water studies. Like so many apparently simple problems, they involve a multitude of details and lesser problems.

The elevation of the water is a fundamental consideration involved in nearly every activity in the Glades. It determines whether or not, and when, an area may be farmed, how high structures should be set, whether water-control facilities are effective or are needed, the height of highway fills, and many other things. Records of stage should be continued long enough to define the extremes of high and low water and to evaluate their variations, as well as the long-time trends. In systems of artificial waterways, the use of stage data is continuous.

Records of discharge show the capabilities and limitations of canals, pumps, and controls; they provide the information necessary to economical improvements and extensions of facilities; they measure the water economy of any area, large or small. It is poor engineering to underdesign water facilities, with resultant ineffectiveness—a case of too little and too late. It is equally undesirable to overdesign and thereby waste money. Good stage and discharge records will help prevent those situations and will point to practical solutions of problems.

The quality of water, an item that has not been adequately covered in the 'Glades, will assume increasing importance in the

future. For some purposes it is not enough to know how high the water may rise or how much there may be. An industrial development must have detailed information as to what is in the water and how its quality may vary. The chemical composition of water is of first importance to municipal supplies and to wildlife investigations. What will be the long-term effect of using certain waters for irrigation of crops? The Geological Survey has been approached at various times for information regarding the chemical composition of surface waters and in some instances no information was available, or it was woefully incomplete. Much work remains to be accomplished in this field and it should be started before the need for the answers arises.

It can be summed up that surface-water studies furnish an inventory of water—its source, how much there is, where it is, its rate of change, where it is going, its chemical characteristics. The collection of water records is comparable to the continuing stock record of an industrial plant. No practical planning can be accomplished without that kind of data. The experience in the 'Glades indicates that in no other part of the country are water records wanted more quickly by cooperating agencies and others—today is none too soon. The cooperators appreciate the long-range view but keep the Survey busy supplying current information. Meanwhile, the records are continuing and they are increasing in value. The water-record needs of the area, however, have not been met and much research remains to be done.

A Typical Detailed Study

When conditions are pertinent to the need for information, the Florida office of the U. S. Geological Survey concentrates its field forces in one area and many observations are made in one day, or longer if the area is large. Figure 1 shows the stage and discharge of West Palm Beach Canal at various places between Lake Okeechobee and Lake Worth on October 20, 1944.

These moderately high flood conditions prevailed shortly after the near-passage of a severe hurricane which caused heavy rainfall in the basin. The profile shows the water surface of the canal as observed at eight places; the profile for September 28 is shown for comparision of the flood profile with ordinary slopes when the main canal flow was all to the east. The water divide, that is, the high point of the canal water surface, occurred at Big Mound Canal with part of the flow from Big Mound Canal moving to the east and part to the west. All flow west of Big Mound Canal was toward Lake Okeechobee and much of it was pump discharge from farms and subdrainage districts. All flow east of Big Mound Canal was toward the Atlantic Ocean, except for the considerable diversion into Cross Canal, most of which ultimately reached the Hillsboro Marsh area and the Hillsboro Canal basin. As far as the extensive farming area near the lake was concerned, the West Palm Beach Canal furnished no early flood relief to the east and could have been temporarily dammed off near Big Mound Canal with more benefit than harm resulting.

Between Big Mound Canal and 20-mile Bend the canal stage was higher than the practically non-existent north bank levee and

Figure 1—Typical area study showing stage and discharge of West Palm Beach Canal under moderately high flood conditions.

water from the open lands to the north had free access to the canal. Note how large a proportion of the increase in flow from Big Mound Canal to Loxahatchee was from unused lands, affording only limited capacity to working lands. Part of this flow was from seepage which could not be avoided, but much was uncontrolled runoff, serving no useful purpose.

Farther east, at Range Line, a discharge of 1,600 cfs. was measured while at the coastal outlet the discharge was 2,940 cfs. This considerable amount of pickup is significant for it shows how large a proportion of the canal capacity is taken by runoff from the coastal ridge. Under flood conditions, West Palm Beach Canal affords little drainage for the Everglades until the coastal area is relatively well drained. It just does not have the capacity to care for all needs.

Studies of this type are highly useful in that they show the distribution of flow—where it is coming from, and how much; they locate the bottlenecks and indicate improvements; they show whether the system is performing a proper job. Similar studies have been made on the other principal canals, in certain areas, and on the whole Everglades canal system. They are applicable to smaller systems such as subdrainage districts, and can point the way to effective improvements and efficient use of existing facilities. Many manhours of work are represented by one area study which requires deployment of a highly flexible but closely coordinated group of engineers.

Evaporation and Runoff Relationships*

Among the more important results of the surface-water studies has been the evaluation of evaporation and transpiration losses in the Everglades area. (The term "evapo-transpiration" will be used hereafter to include both evaporation and transpiration losses, which cannot be separately identified at the present status of the sciences concerned.) Such losses are particularly elusive to the investigator and are practically impossible to compute directly.

By subtracting the measured runoff from the main Everglades basin from the average rainfall an approximation of evapo-transpiration was obtained. Such losses, based on three years of record, ranged between 39 and 47 inches and averaged 43, or about 75 percent of the rainfall. These data do not include adjustment for small differences in initial storage and the indeterminate but probably relatively small amount of ground-water flow directly to the sea. Thus, evapo-transpiration is the largest drainage factor in the Everglades and man can exercise little control over it.

Evapo-transpiration losses were also computed by using the longer-time records for the lower Kissimmee River. These data were more susceptible of conclusive results because they apply to a natural uncontrolled river basin as compared with the controlled Everglades canals. Surprisingly enough the losses in the Kissimmee River basin indicated 42 inches of loss to the atmosphere with little variation for widely varying general water conditions. Figures 2, 3

* The illustrations and most of the data in this section are from General hydrologic analyses, Chapter XI, Water resources of southeastern Florida, U. S. Geol. Survey 1945; released in preliminary form to cooperating agencies, general publication expected 1948.

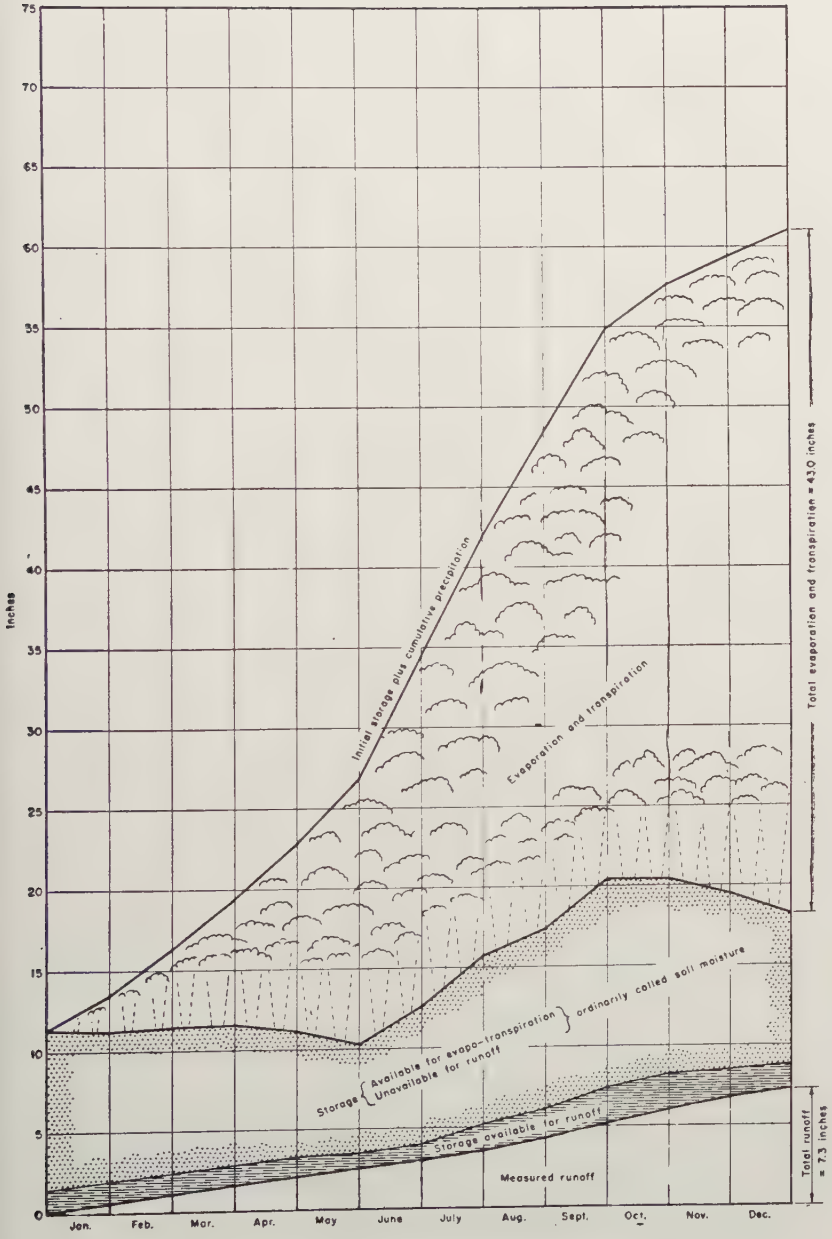

Figure 2—Hydrologic inventory during average year, Kissimmee River near Okeechobee, Florida.

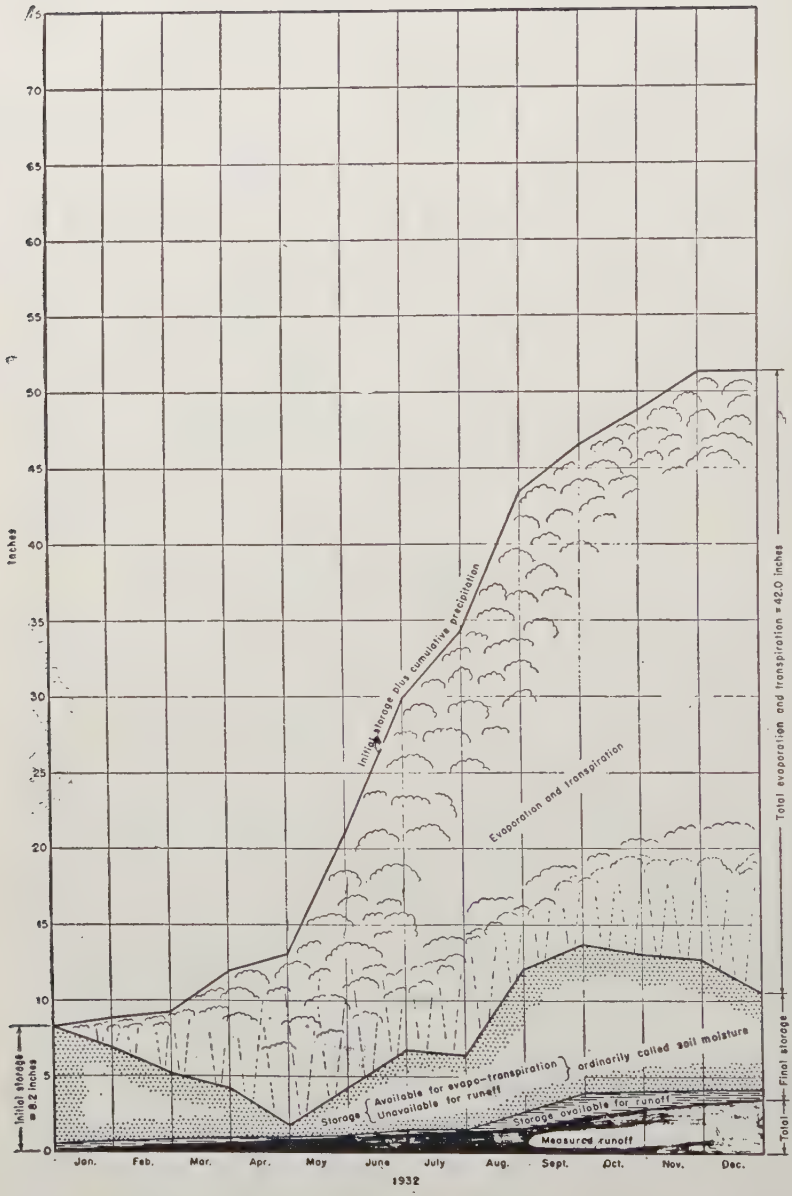

Figure 3—Hydrologic inventory during typical wet year, 1934, Kissimmee River near Okeechobee, Florida.

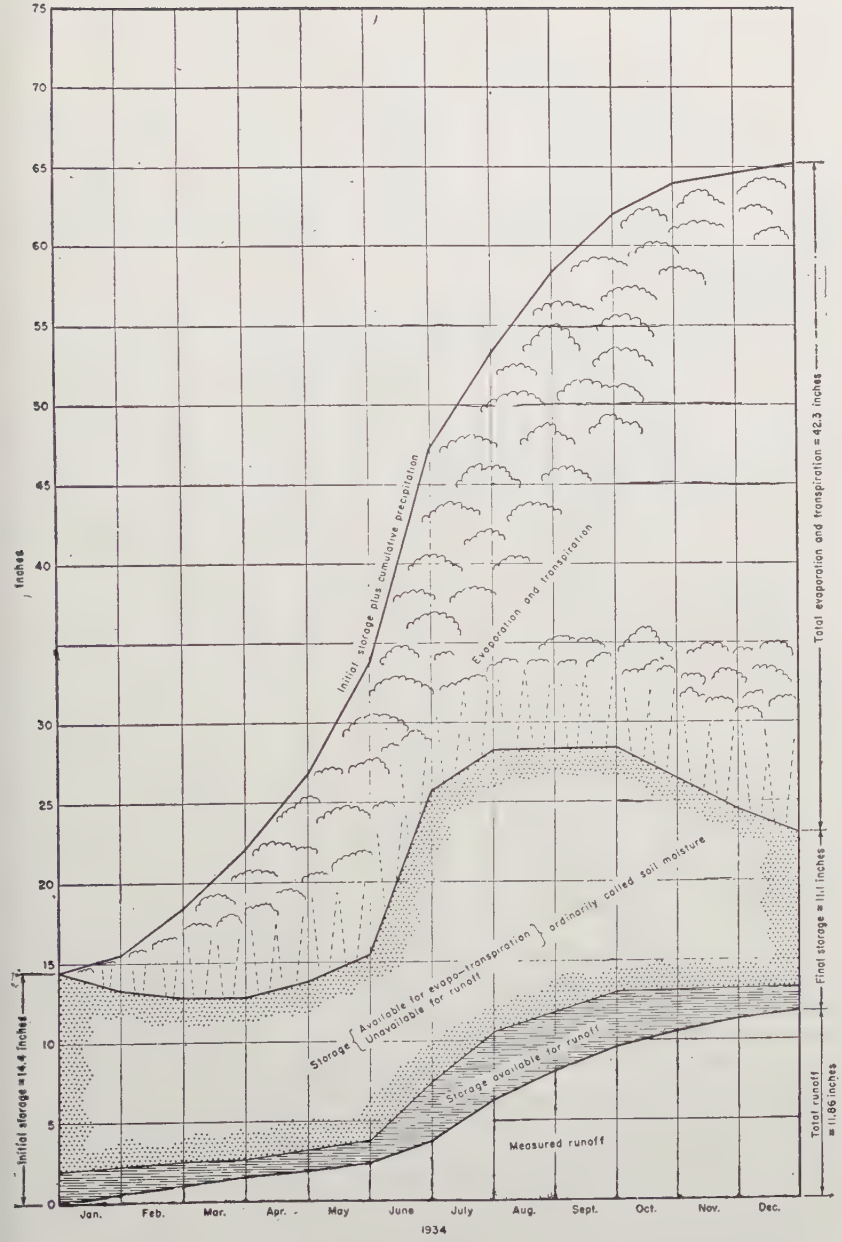

Figure 4—Hydrologic inventory during typical dry year, 1932, Kissimmee River near Okeechobee, Florida.

and 4 show water relationships in the Kissimmee River basin for average, wet, and dry years, respectively. All the values shown are in inches of water over the entire basin, a means of comparison with rainfall which is usually reported in inches.

The lowest curve shows the runoff as measured at the State Highway 70 gaging station. It is cumulative from the beginning of the year and is the most accurate determination of the several involved. The next curve above defines the ground storage available for runoff, the water table ground water. A horizontal graph is indicative of no recharge and means that out-flow is wholly at the expense of storage.

The third graph envelops soil moisture, storage available for runoff, and runoff. At the beginning of the year its height represents the initial storage and the quantity varies during the year as affected by the other factors. Soil moisture is that water which the soil will not release by gravity but that can be lost through capillary action to the surface where it evaporates or through plant root systems and subsequent transpiration. This moisture has an important part in the hydrologic inventory and is the principal source of the evapo-transpiration losses. Its quantity may change considerably during a year and even approach zero in drouth conditions. The third graph is the only one of the four which can slope downward to the right, as indicated in the continuous water inventories.

Above the other factors the fourth curve represents cumulative precipitation and it starts at the amount of initial storage. It is the supplying factor from which all the others derive as affected by climate, vegetation and geography. Note that the vertical distance between the third and fourth curves is a measure of the cumulative evapo-transpiration losses.

The most startling observation in connection with these typical water inventories relates to the constant evapo-transpiration losses. Here, then, is the key to drouth conditions—a new loss of available water occurs. Precipitation may be low, runoff and depletion of the ground water continue in some degree, therefore the soil moisture is drawn upon heavily. In some years the rainfall may be less than the evapo-transpiration. And when serious rainfall deficiency occurs two years in a row, as happened in 1944 and 1945, extreme drouth conditions prevail. It might reasonably be expected that when drouth continues for a long period, the evapo-transpiration will necessarily decrease. When this occurs the vegetation suffers, for the root zone has not enough water to support plant life.

Another interesting observation relates to the effect during a wet year. Under the effect of heavy rainfall, soil moisture and ground storage increase more rapidly than runoff and flood conditions obtain. A sizeable time lag exists between precipitation and runoff in flat basins such as are found in south Florida.

These studies should be extended, as there is need for further evapo-transpiration information. A considerable mass of data exists which has not yet been evaluated. Correlation studies between small-area observations and these basin computations are needed to develop coefficients for utilizing the small area data. Early results indicate

that test pan evapo-transpiration losses are too high to be usable directly.

Some General Notes

Once again, questions may be heard: "You've done a lot of work, but what good is it? We know when it's too dry, when it's too wet. We've been here through it all! We know evaporation is a big factor." It is sometimes difficult to answer the sincerely puzzled layman because there is usually not time enough to present a short course in hydrology and engineering. But the answer is that when design and development of improvements and facilities are initiated, definite data to work with must be had. "Horse-back" estimates have their place but there comes a time when positive information is necessary. Basic data cannot be produced instantaneously because time is one of the main coordinates of water records.

It has also been found that human memory is all too fallible. People tend to forget just what did happen: at least, the memory becomes too hazy to be of practical value. The extremes of dryness and wetness make a big impression, for a while, but the ordinary course of events is often minimized. Extremes are important, very important, but the variations and trends between must not be overlooked. Careful systematic water records will furnish much of the background for further development of Florida. The quantity of water available is an absolute limitation on all development.

And to answer the questioner more concretely, let us study the importance of the hydrologic inventory. Evapo-transpiration amounts to 75 percent of the rainfall in an average year. That leaves 25 percent to be accounted for elsewhere. Some of the 25 percent is involved in net changes in soil moisture and ground water—the change in storage. The remainder is wasted by drainage to the sea, either by overland flow to the south or in the canals. The word "wasted" is used in the sense that the water cannot be recovered, although some of the water loss is necessary to the use of the land. Since it is probable that little can be done to reduce the great evapotranspiration losses, the water being drained to the sea is what might be called the controllable factor.

Despite the fairly large annual rainfall in south Florida, unfortunately it is usually poorly distributed, from man's viewpoint. Much of it occurs from June to September. If farming is to be carried on, drainage operations are required to minimize the rainfall unbalance. Even in dry years, some measures of drainage is necessary. Consider a dry year: rainfall 41 inches; evapo-transpiration 43 inches; runoff, or drainage, 5 inches. The net loss for the year was 7 inches which came out of storage. Everything seemed fine at the start of the farming season as crops were planted early. But as the ground-water table declined and soil moisture decreased, the plants began to need more water than the soil could supply. The answer to that seems obvious—irrigate. So irrigation was started and water for plant use was artificially supplied. That was satisfactory until, as some areas in the Everglades learned by the hard way, there wasn't enough irrigation water. Either the local supply dwindled below pump capacities, or the canals were not adequate to deliver water from other areas, or the other areas had no excess to

release. So the hard fact was learned that seasonally there is none too much water in the 'Glades and that it cannot be wasted with impunity. No water source is "unlimited." Continued practical development required means for recharge of water supplies. It is well said that man cannot break natural law—but certainly natural law can break man.

So in the early days of the 'Glades, with an unlimited rosy horizon, the lessons available in nature were overlooked. Water was an enemy to be routed and removed. In the light of recent studies and experiences, observers believe that the runoff water must be retarded; that if provisions can be made to store part of the runoff during the wet season, more will be available in the dry season. They believe the answer to many of the water problems of the 'Glades is to delay runoff, either by canal or overland. Every day that the soil is kept wet beyond the time it would usually become dry, will keep the soil for the future and reduce losses by oxidation and fire. Every additional day that irrigation can be maintained in the dry season will mean a more secure agricultural economy.

Stark reality finally forced this change in thinking and now we see the creation of water-conservation areas. Great areas of land suited principally to water storage have been planned by the Everglades Drainage District. Instead of running all the now wasted water to the sea in the summer and fall, as much as possible will be diverted to the water preserves. The lesser part of the rainfall, the controllable part but the balancing factor, will be available in these reservoirs. Storage for flood runoff will benefit the coastal ridge; water available for irrigation will benefit all interests. The changes involved will not be great in any one locality. Water events in the 'Glades deal in a couple of feet, a foot, a part of a foot.

The stored water will be available in two ways. It will move by underground seepage as modified by the drainage system. This will be a slow process that will raise water levels to the southeast and south of the water preserves, depending upon the locality. It will also seep into the canals and will be available for irrigation and maintenance of desirable water levels in farmed areas. In times of flood, the water preserves will provide storage capacity and thus relieve the over-burdened canals, although it will still be necessary to route some of the water to the sea. However, less will be wasted, and the delaying process will be functioning.

The U. S. Geological Survey has been fortunate in seeing a comprehensive plan of water control for the Everglades evolve in recent years and has taken some pride in supplying basic information for that plan. Those of us in the field believe, within our official limitations of approval, that the water-conservation areas are a proper part of a coherent practical plan and that their establishment will lead to better water control and more stable economy in the 'Glades. The Survey expects to continue to help local agencies determine their problems and to have a part in the impartial evaluation of improvements.

There is no one solution to water control in the 'Glades. No one improvement will effect startling changes over a large area. But each improvement will make a contribution and the effect of these

contributions will be cumulative, with the curve of total improvement rising faster and faster. Nature's precept was ignored in the beginning but it is now being appreciated. With the working facts of the case available, and more to be obtained, the Everglades would seem to be on the threshold of a new and better era.

MUNICIPAL WATER - SUPPLY PROBLEMS OF SOUTHERN FLORIDA *

Mr. Garald G. Parker**

Background.—This paper results from investigations made by the U. S. Geological Survey of the geology and ground water of much of southern Florida. These investigations were made in financial cooperation with the following public agencies or governmental units: the Florida Geological Survey, Dr. Herman Gunter, Director; the County of Dade, Earle M. Rader, County Engineer; the City of Miami, William A. Glass, Director of Department of Water and Sewers; the City of Miami Beach, Claude A. Renshaw, City Manager; City of Coral Gables, William T. McIlwain, City Manager; the City of Fort Lauderdale, J. H. Philpott, City Manager; the City of Delray Beach, H. P. Edmond, City Manager; the City of Fort Myers, David H. Shapard, Mayor; the City of Fort Pierce, B. Arnold, City Manager; and the City of Lake Worth, Tom J. Smith, Mayor.

A large amount of additional information was also gathered during the war when water supplies were in serious and immediate demand at numerous Army, Navy, Coast Guard, and Defense Plant Corporation and other privately owned industrial establishments. Previous reference (Parker, 1942, p. 50; Parker and Hoy, 1943, p. 33; and Parker and Hoy, 1944)*** has already been made to the information gained through cooperation with the U. S. Conservation Service in the drilling of 30 test wells in the Everglades.

Acknowledgements.—The writer is indebted to many persons for aid in the preparation of this report, especially to colleagues in both the U. S. and the Florida Geological Surveys. Among those whose help is deeply appreciated are the following: Dr. A. N. Sayre, Chief, Division of Ground Water; V. T. Stringfield, Senior Geologist, C. L. McGuinness, Geologist, and R. W. Sundstrom, Engineer, all of the Division of Ground Water; S. K. Love, Chief, Division of Quality of Water; Dr. Herman Gunter, Director, Florida Geological Survey, and Nevin D. Hoy, Associate Geologist, whose assistance in the field, office, and laboratory has been of inestimable value. All have critically read the manuscript. Ross A. Ellwood, Engineering Draftsman, prepared the illustrations and M. Marvine Melton typed the manuscript.

Present report.—The area covered in this report includes that part of peninsular Florida that extends from the southern tip of Monroe County (Key West), northward to the approximate latitude of the southern boundary of Orange County. (See fig. 1, index map.)

* Published with the permission of the Directors of the U. S. and Florida Geological Surveys.

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*** See references,

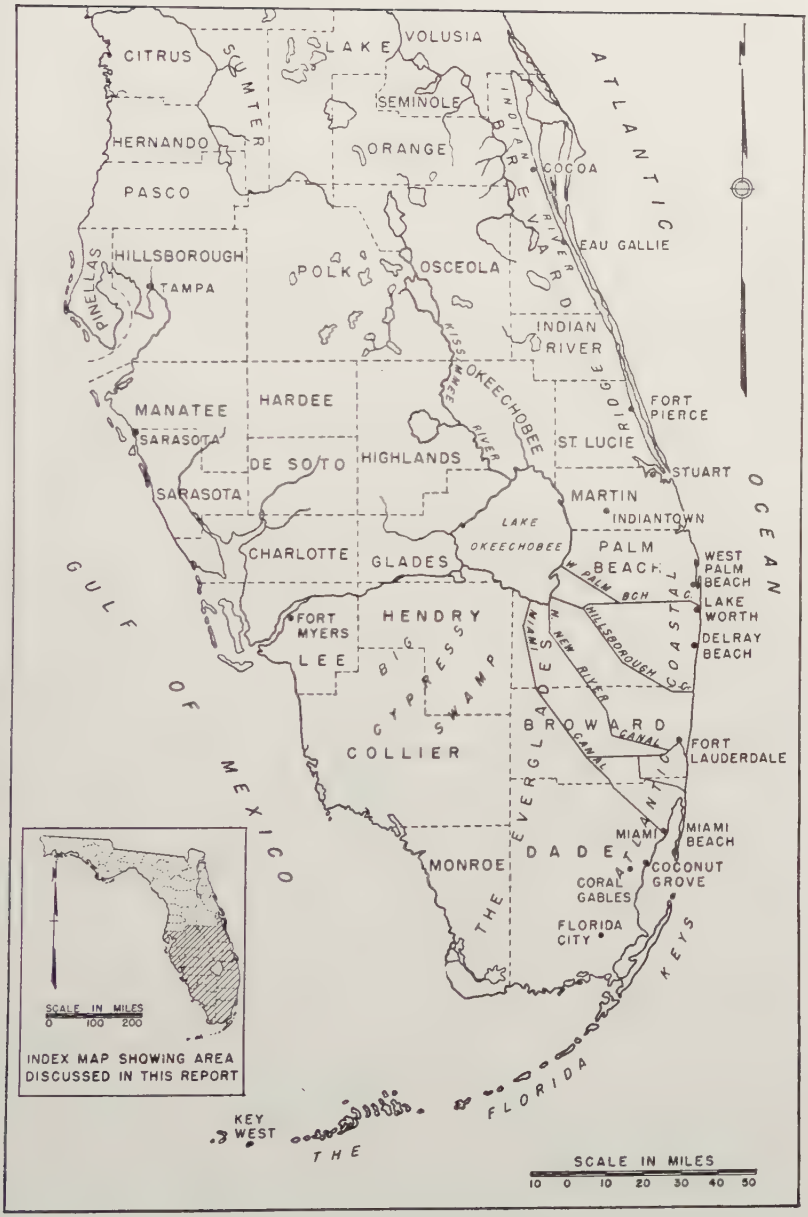

Fig. 1 Map of Southern Florida

This report is intended to be only a general treatment of the problems of municipal water supplies in the area. Therefore, detailed geologic and hydrologic data, and pumpage figures and related

data for each municipality in the area of the report are not given—in fact, for many of the smaller towns such data are not available because adequate records are not always kept. A general treatment of the problems, and of the factors controlling occurrence and development of water available for municipal use is given, and some data on water consumption by separate counties are presented. These data are broken down for requirements of industry, agriculture (rural and irrigation), and municipalities.

Development of Water Supplies in Southern Florida

Early conditions.—When early settlers came to southern Florida they found a virgin land blessed with a subtropical climate, and water in such great profusion that it was generally considered a nuisance. The Everglades and Big Cypress were perennially flooded, and vast stretches of wet prairie and swamp occupied much of the rest of the interior, including the Kissimmee Valley. These flooded conditions and lush vegetation made travel in the interior difficult (Willoughby, 1898; Senate Doc. 89, 1911) and caused most of the early settlements to be made along the Atlantic and Gulf shores.

The rich black organic soils of the glades excited the imagination of some of these early comers, and although many of them settled along the coastal zones to enjoy the salubrious climate, others hied into the "black country" for agricultural pursuits and drainage became their obsession (Senate Doc. 89, 1911).

However, for those who settled in the pleasant little hamlets along the coast of southern Florida it mattered little what the drainage enthusiasts did. These coastal dwellers found all the fresh water they needed right at their doorsteps. It was only necessary to utilize water from any of the numerous springs that flowed in many places along the shore at or near the base of the Coastal Ridge (Munroe, 1930, p. 218). Or, lacking a spring on one's property, it was simple to dig or drill a well anywhere and obtain all the pure, fresh, clear water that one could use. In fact, in those early days great springs of fresh water bubbled up through the floor of Biscayne Bay, and are reputed to have existed off the shore in the ocean in many places. Off the Coconut Grove docks in Miami a well had been driven through the salt water of the Bay into the underlying fresh water, and boatmen would tie up to the casing of this well and obtain potable drinking water from it (Munroe, 1930, photograph opposite p. 118).

Later developments.—With the passing of time word spread of the wonderful climate of southern Florida, and hundreds of thousands who came to see stayed and established homes and businesses. The drainage enthusiast had succeeded, by 1918, in accomplishing the dredging of most of the major Everglades drainage canals, and a thriving agricultural economy became established on the black organic soils of the glades.

The cultural development was greatest, however, along the Atlantic and Gulf coast where "tourism" became one of southern Florida's biggest and most lucrative businesses. Here the numerous urban centers grew and prospered, many of them achieving phenomenal rates of growth for permanent settlements.

As these settlements grew, the development of water supplies

TABLE I

ANALYSES OF SELECTED RAW GROUND WATERS

IN

SOUTHERN FLORIDA

Locality	Date	Color	pH	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sodium and potassium (Na plus K)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as ($CaCO_3$)
Belle Glade (S353, deep Artesian well)	1941	10	—	3,170	—	0.3	166	131	—	264	—	22	5.8	1,990	—	—	953
Boca Raton (composite M.S.)1/	1941	10	7.2	195	9.6	0.06	59	3.1	—	2.6	—	168	2.0	18	0.3	0.7	160
Fort Lauderdale (G 221 -314' L. S.)	1941	5	—	5,100	—	—	110	139	—	1,650	—	100	333	2,720	—	—	846
Fort Lauderdale (composite M.S.)	1941	110	7.3	294	11	1.9	88	3.3	11	—	1.4	266	2.4	18	0.1	2.1	233
Fort Lauderdale (S 567, deep artesian well)	1946	3	7.3	6,570	—	—	183	248	—	1,900	—	165	685	3,380	—	0.5	1,480
Fort Myers (L-38 shallow artesian)	1944	14	8.2	391	—	0.04	72	29	—	40	—	235	11	100	0.4	0.2	298
Fort Myers (composite shallow well field Well No. 2)	1946	62	6.2	571	—	—	114	6.1	—	44	—	241	70	94	—	1.7	310
Fort Myers (L 130 deep artesian)	1944	1	7.4	2,010	—	0.1	142	107	—	441	—	156	343	909	—	—	794

TABLE 1 CONTINUED

Locality	Date	Color	pH	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sodium and potassium (Na plus K)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as ($CaCO_3$)
Fort Myers (L 246 new well field area)	1945	52	7.1	320	—	1.5	122	3.6	—	23	—	388	1	35	—	0.6	320
Hollywood (composite M.S.)	1941	40	7.1	333	3.2	0.24	103	2.6	—	10	—	301	19	17	0.2	0.1	268
Homestead M.S.	1941	5	—	212	2.8	0.02	63	6.5	—	7.2	—	218	8.3	10	0.2	0.3	184
Kraemer Island (GS-26 -42' L.S.)	1943	240	6.9	2,780	—	0.04	176	180	—	646	—	1,305	221	910	—	—	1,179
La Belle (M.S. deep artesian)	1941	5	—	1,595	26	0.16	65	53	—	349	—	118	325	500	2.4	—	380
Lake Worth (composite M.S.)	1941	40	—	287	4.8	0.72	74	3.1	—	19	—	220	20	25	0.1	4.0	197
Miami (composite M.S.)	1941	85	6.8	370	7.4	1.3	94	9.6	22	—	2.2	266	34	38	0.1	1.5	274
Moore Haven M.S.	1941	80	—	487	8.4	2.2	104	13	—	25	—	312	44	43	0.3	5.0	313
North Miami M.S.	1941	60	7.5	333	5.2	0.32	99	3.8	—	8.2	—	255	47	16	0.2	0.1	263
North Miami Beach M.S.	1941	40	7.1	1,279	7.6	1.5	176	3.3	—	132	—	285	25	340	0.2	0.0	453
Opa Locka M.S.	1941	70	7.2	244	3.0	0.68	72	4.5	—	5.1	—	216	16	11	0.3	0.1	198

Note: Analyses by U. S. Geological Survey.

For some of these and additional analyses see: Love, S.K. and H. A. Swenson "Chemical character of public water supplies in southeastern Florida", A. W. W. A. Jour., Vol. 34, No. 11, pp. 1421-1428, 1942. 1/ Municipal supply.

progressed through several stages. Simplest was that in which each householder furnished his own supply; next was that in which the community, or a water company franchised by the community, developed a municipal supply and pumped untreated raw water to consumers. From this stage on there have been many refinements, depending principally upon the type and extent of treatment the water is given before it finally reaches the consumer. At present there are communities in all stages of these developments and some are now very modern. For example, Miami, Fort Lauderdale, and West Palm Beach treat raw water with elaborate and costly processing. Such treated water is of excellent quality and compares favorably with municipal supplies anywhere in the world.

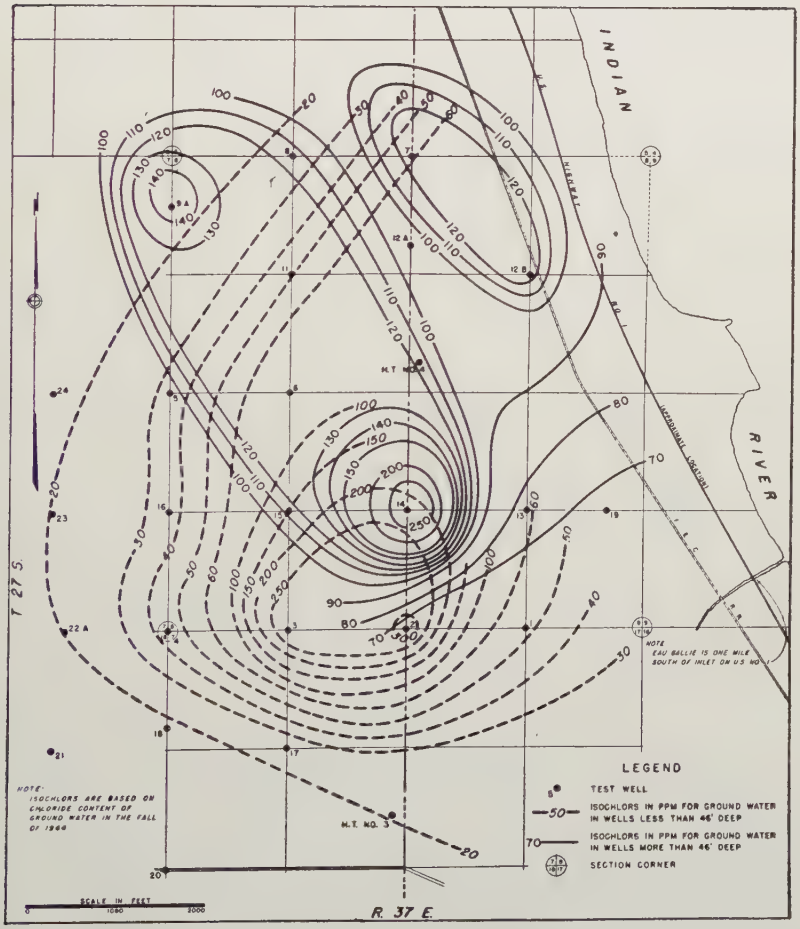
INDIAN
RIVER
T 27 S
R. 37 E.
M.T. NO. 3
LEGEND
TEST WELL
ISOCHLORS IN PPM FOR GROUND WATER IN WELLS LESS THAN 46' DEEP
ISOCHLORS IN PPM FOR GROUND WATER IN WELLS MORE THAN 46' DEEP
SECTION CORNER
NOTE: ISOCHLORS ARE BASED ON CHLORIDE CONTENT OF GROUND WATER IN THE FALL OF 1944
NOTE: EAU GALLIE IS ONE MILE SOUTH OF INLET ON U.S. NO. 1
SCALE IN FEET
0
1000
2000

Fig. 2 Map of a part of the Atlantic Coastal Ridge in Brevard County, Florida, showing Isochlors in Ground Water of two separate Shallow Horizons in the Fall of 1944.

Problems of development of municipal supplies.—At first, in most places it was relatively easy to develop the small quantities of water needed, and usually these supplies were developed from wells, the location of which was primarily dictated by factors of economy and geography. However, there are some places where this easy development is not possible. For example in the upper and middle Everglades and around Lake Okeechobee good wells are few and far between. The underlying rock materials are generally of low permeablity and salty ice-age water that has been trapped at shallow depth under much of the Everglades makes it almost impossible to obtain potable well water. A chemical analysis of such water is given in Table I, for well GS,26 which is located on Kraemer Island near the southern shore of Lake Okeechobee.

The greatest concentrations of chloride in this shallow salty ground water are at depths of 40 to 45 feet around the southern and southeastern shores of Lake Okeechobee and extend well south into the Everglades. Parker (1942), Parker and Hoy (1943), Parker, Ferguson, and Love (1944), and Parker and Hoy (1944) have previously discussed this problem. Salty water has also been found to underlie the Fort Lauderdale well field area at depths of about 165 feet and more (Vorhis, 1947). See also Table 1, well G 221, for analysis of such water near the Fort Lauderdale water plant at a depth of 314 feet below land surface.

Along the Atlantic Coast in Brevard County similar conditions also exist. Bodies of salty ground water and materials of low permeability have combined to make difficult the development of groundwater supplies. Figure 2 shows an area of the Coastal Ridge in Brevard County north of Eau Gallie, and indicates the chloride content of the shallow ground water at two separate horizons there. This map was prepared as a result of assisting the U. S. Navy in 1944 on its search for a suitable water supply for the Banana River Naval Air Base.

In the Gulf Coastal counties, beginning at the north with Hillsboro and Pinellas Counties, somewhat similar salty ground-water conditions are known to exist, although the shallow ground water is generally not so saline as in parts of Brevard County. In these Gulf Coastal counties the earliest municipal supplies were obtained from the deep artesian waters which are sulfurous, hard, and more or less saline (see Table 1, for analyses of these deep artesian waters. Analyses are given for wells of the Fort Myers and Belle Glade areas). These waters were not always acceptable even with the best treatment that could be given them and certain cities, for example Fort Myers, Sarasota, and Tampa, either have already abandoned the deep artesian water for shallower ground water or have begun to use surface water.

Fort Myer's experiences may be used as illustrative. Up to 1937 the city had used deep artesian well water, but this sulfurous, saline water was not satisfactory so in 1937 a shallow well field comprising 13 wells about 36 to 38 feet was developed near the present water plant.

This well field furnished an excellent grade of raw water until 1942 at which time it became obvious that the well field was being

over-pumped; furthermore, it was noted that salty water from the Caloosahatchee River was contaminating that part of the field nearest the river. Therefore, a new shallow well field was developed a few blocks away from the first field, and together with the water from field No. 1 sufficed until the demands of the war-swollen population for increased water caused the second field also to be over-pumped.

Faced with these conditions the City Commissioners, upon the recommendation of Dr. A. P. Black, Consulting Engineer, requested a cooperative study of the water resources of the area to determine what should be done.

This study was made in 1944 and 1945 and resulted in the location of a comparatively large area underlain by a permeable shallow aquifer, and sufficiently removed from the Caloosahatchee River to be safe from salt water encroachment. The site is only a few miles east of the municipal water plant.

Pumping tests made in this newly discovered area indicate a coefficient of transmissibility of about 40,200, which means that under a hydraulic gradient of 1 foot per mile 40,200 gallons of water a day would flow through a section of the aquifer 1 mile wide. This indicates that a sufficient quantity of water in the new area may be obtained for any forseen population growth by the City of Fort Myers.

While this research was going on the City, in order to supply sufficient water to meet the demand, has had to augment the water from the two shallow fields with deep artesian water. The resulting mixture was highly unsatisfactory but the best that could be done under the circumstances. And, to further aggravate the water supply problem, shallow well field No. 2 was ruined in 1946 by phenol wastes from a newly established industry located nearby. This necessitated a still larger proportion of the water furnished the users being composed of deep artesian water, and resulted in a further lowering of the quality of the water. At the present writing the development of the new field east of town is nearing completion and before much longer Fort Myers will have a highly satisfactory water supply.

It is believed that other cities of the Gulf Coast, such as Tampa and Sarasota could, with adequate geologic and ground water studies of the shallow aquifers of nearby areas, also develop very satisfactory ground water supplies. St. Petersburg is an example of another Gulf Coast City that abandoned salty ground water and developed an excellent supply of fresh ground water.

Key West, at the extreme southwestern end of the Florida Keys, for years used mostly cistern water, caught on roofs during rains and conducted by spouts into cisterns. Also, there were numerous shallow wells, up to about 15 feet deep, furnishing limited family supplies of more or less brackish water. The surface of the water in these shallow wells rises and falls with the tides. To augment these water supplies additional water was hauled or shipped in, or supplied at the Naval Base by a large distilling plant that used sea water.

Research by the U. S. Geological Survey in cooperation with

the U. S. Navy Department in 1941 disclosed that no local supplies of fresh water of any considerable quantity exist on the Florida Keys at either shallow or great depths. Therefore, a supply was developed on the mainland southwest of Florida City, and water is piped to Key West through an 18-inch line.

At Fort Pierce in St. Lucie County, the municipal supply was developed in the "Savannah", a narrow muck-bottom saw grass swale several miles long, lying parallel to Indian River and separated from the salt water of Indian River by a thin strip of sandy beach ridge. This supply was not always reliable for in time of drouth the Savannah dried out; therefore, six shallow artesian wells were drilled in 1939 to replace or augment the surface water of the Savannah.

At Indiantown, in Martin County, great difficulty had been met in obtaining municipal supplies. Local shallow wells supply households, but no driller had ever been successful in making a municipal well field. For a time surface water from the St. Lucie Canal was used, but the quality (color and organic sediment, especially) was unsatisfactory. Later, following studies by Dr. A. P. Black, Consulting Engineer, Gainesville, Florida, and this Survey, a shallow well field was developed in 1946 which has proved to be highly satisfactory.

Along the Atlantic Coastal Ridge, from Stuart south to Florida City, there are only a few places where difficulty exists in developing adequate ground-water supplies. There are other problems, however, that must be considered, most important of which is that of salt-water encroachment.

It has been shown already (Parker, Ferguson, and Love (1944), Parker (1945), and Brown and Parker (1945) that salt-water encroachment from the ocean in south Florida takes place in two separate but related ways: (1) up tidal canals into areas of fresh water during times of drouth when tides in the ocean are higher than inland water levels, and (2) by underground seepage directly from the ocean into the fresh-water aquifers (natural underground reservoirs) as a consequence of an upset equilibrium between fresh and salt water.

The first type of enroachment was responsible for the salting of the Miami Springs-Hialeah well field of the City of Miami in 1939 and again on short occasions in several subsequent years. This kind of encroachment takes place by leakage of relatively heavy salty water out of the sides and bottoms of tidal canals, replacing the less dense fresh water in the aquifer. The amount of damage done is largely dependent upon several factors, among them: (1) concentration of salt water in the canal, (2) length of time salt water occupies the canal, (3) presence or absence of a relatively impermeable silt layer in the canal, (4) permeability of the rocks through which the canal is cut, (5) pumping of large quantities of ground water near the canal, (6) relation of the water table to canal stage.

Wherever tidal canals or other streams connecting with ocean water exist in south Florida, contamination can and does take place in this way. It is the type of encroachment principally responsible for ruination of the numerous wells in Dade and Broward Counties

in coastal zones along the drainage canals, examples of which are those of the New River Basin and of Snake Creek, Little River, Biscayne Canal, Miami Canal, Coral Gables Canal, and the numerous other canals in southern Dade County.

The second type of encroachment from the ocean takes place because there is no longer an adequate head (or weight) of fresh water above mean sea level to hold salt water out to its original pre-drainage location. The heavier salt water was once held at some off-shore position by weight of fresh water on land that averaged in the Miami area almost 5 feet above mean sea level very near the shore line. Where the fresh-water head was 5 feet it was sufficient to hold salt water to a depth of about 200 feet below mean sea level. As the aquifer extended to about 100 feet below sea level, it held only fresh ground water (Parker, 1945). Now, however, in Dade County and much of Broward County drainage has so lowered the height of fresh water above mean sea level that water levels very near the shore line average less than half a foot above mean sea level, and elsewhere in south Florida where drainage has been highly successful the water levels likewise have been lowered materially. Under these changed conditions the long-established equilibrium between fresh and salt water in the coastal area has been upset and sea water has encroached. It will continue to do so until a line is reached, roughly paralleling the shoreline, where the average height of the water table is sufficient to depress salt water to the very bottom of the aquifer. In accordance with the Ghyben-Herzberg principle (Brown and Parker, 1945) each foot of fresh-water head above mean sea level in the coastal zone of contact between fresh and salt water will depress salt water about 40 feet, depending upon the density of the salt water. In the Miami area, where the aquifer is about 100 feet thick, about 2½ feet of fresh-water head above sea level will be required (2½ x 40—100); in the Fort Lauderdale area, where the aquifer is about 160 feet thick, 4 feet of fresh water above sea level will be required (4 x 40—160).

The rate and pattern of inland movement of salt water under the upset equilibrium now existing in southern Florida depend not only on average height of fresh water above mean sea level but also upon the permeability of the rock materials through which the salt water passes. The distribution and areal extent of layers or lenses of relatively impervious materials (clay, silt, and very fine sand or mixtures of these with marl) may be such that salt-water encroachment will occur in one area but will be prevented in an adjacent area. Miami has already lost two of its well fields to this type of encroachment—the Spring Gardens field (Sewell, 1933, Chapter 6) in 1925 and the Coconut Grove field beginning in 1939.

Elsewhere in southern Florida experience with salt-water encroachment has not been greatly dissimilar. Salt water has invaded some city and private wells in Sarasota County and is now creating an especially vexing problem in Pinellas County. This is not due to drainage, as in Dade County and contiguous areas, but to a lowering of the pressure in the artesian aquifers that supply the ground water of Sarasota and Pinellas Counties, caused by withdrawal of water through wells. Salt water from the Gulf of Mexico

moves into these artesian aquifers under an upset equilibrium in accordance with the Ghyben-Herzberg principle, even as it does in the over drained non-artesian aquifers along the Dade-Broward coastline of southeastern Florida.

Mention has already been made of the encroachment in the New River Basin in the Fort Lauderdale area. At Fort Pierce the well nearest Indian River (City well 8) started showing increasing chloride in 1941, only 2 years after the Fort Pierce wells had been installed. Other examples might be cited. However, those cited show the trend of salt water moving inland, replacing fresh water of the coastal area that was once supposed to be an inexhaustible and dependable supply.

Another problem of municipal water supplies in some areas is that of connate or residual bodies of salty water underlying the areas in which well fields are or may be developed. Unless great care is taken in the original development and subsequent pumping of such wells, salty water from below the well field may rise to contaminate the supply, and could eventually ruin it. Such condition is now known to exist in the Fort Lauderdale well field area, and future developments there, as well as continued use of the present wells, must take this condition seriously into account (Vorhis, 1947). Probably other communities besides Fort Lauderdale are in a similar situation; therefore all responsible city officials must know whether or not their present or future well supplies could be ruined by such upward movement of salt water. Some of the contamination noted of artesian water in Hillsboro and Pinellas Counties may be of this origin, rather than from the Gulf of Mexico at the present time. A study of the chemical properties of the contaminated water would have to be made to determine this.

Still another set of problems relating to municipal supplies deals with contamination or pollution of the water by nearby industries. Recently Fort Myers, Florida, lost a well field owing to phenol wastes from a wood-processing plant that treats fence posts, railroad ties, telephone and telegraph poles, piling, etc., with coal-tar products. The plant was built and operated within a quarter of a mile of the well field, and within a few months the phenol taste was so strong that the field could no longer be used. In Dade County wastes from a gas plant have caused phenol tastes in private wells and one municipal supply (North Miami Beach).

Another industrial waste problem is that springing from the rapid development of the self-service type of laundries. These are ordinarily located in comparatively small buildings and have no adequate treatment process for waste water, or give the waste water no treatment whatever. In cities lacking adequate sewerage systems this water with its accumulated filth is dumped directly into the ground-water wells. Where such wells end in salt water the practice is not deleterious to municipal or private water supplies, but where such wells end in a part of the aquifer that contains potable water a dangerous situation may develop.

Still another set of problems arises out of continuous growth of the urban population, which creates an ever-increasing demand for water supplies. Parker, Ferguson and Love (1944, p. 13) have pointed

out that in southeast Florida coastal municipal water supplies come from no great distance in the hinterland, but instead are mostly dependent upon rain water falling directly upon the Coastal Ridge. This puts a definite limit upon the amount of water that may be safely withdrawn without causing salt water to move in from the ocean to replace the pumped water. However, this limit is not known for the entire coastal area of southern Florida, because detailed long-term studies are necessary to determine it. The U. S. Geological Survey, in cooperation with the Florida Geological Survey and several communities and county governments in southern Florida, has been working on this problem for some time but much more needs to be done before safe limits of withdrawal everywhere will be known.

Studies made to date, however, indicate that at present far more water is available than is being used and that considerably greater development of ground water can be made before the danger point is reached if it is done wisely.

Many municipalities of southern Florida are at present urgently engaged in plans for enlarging or expanding water supplies. Before the war these municipalities had already reached the limit of their

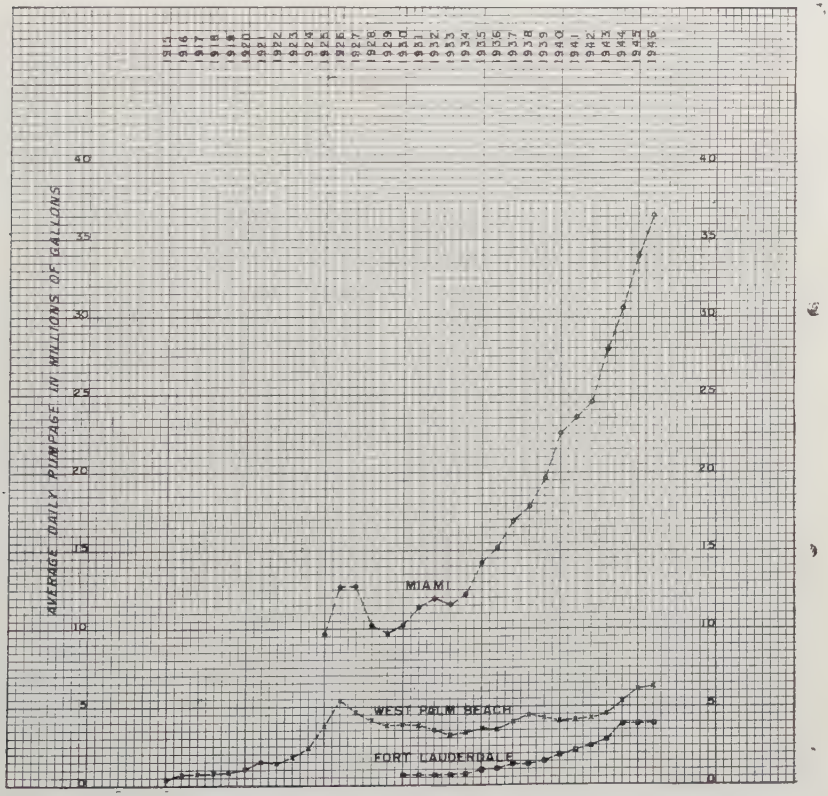

Fig. 3 Graph showing average Daily Pumpage by years at Municipal Water Plants of Miami, West Palm Beach, and Fort Lauderdale.

water-supply facilities, and were unprepared for the wartime demands. They were unable to get materials, supplies, and labor for expansions. Since the war the demand for water in some places has diminished but in most places more water than ever is needed and the problem is becoming more acute.

The expansion of municipal water supplies will continue as long as population increases; thus greater and greater demands will need to be met and more and more ground water will be required (see Fig. 3). It does not seem improbable that in the near future the entire lower east coast (West Palm Beach southward to Florida City at least) will become largely a thickly populated urban area, composed of numerous communities that have expanded westward to the Everglades and coastwise to meet adjacent settlements, much as West Palm Beach, Lake Worth, Lantana, Boynton, etc., or Ojus, North Miami Beach, North Miami, Coral Gables, South Miami, Kendall, and others are now doing. As this urban growth develops, the need for adequate supplies of ground water will become very great and competition between cities and industries for adequate, safe supplies may become keen. These anticipated needs must be planned for, based on adequate investigations of the ground water resources so that overdevelopment and unanticipated interference between separate developments in any given area may not take place.

As an example of past development the graph, Figure 3, was prepared. It shows the increased use of water by years from three selected municipalities of the lower east coast that are regarded as typical. Miami and Fort Lauderdale use ground water and are selected as examples of large and middle-sized communities, respectively. West Palm Beach is the only middle-sized community on the lower east coast using surface water exclusively.

Still another set of problems arises from the increased use of ground water for other newly developed purposes such as air conditioning. The great expansion in air conditioning began only a few years ago. In southern Florida, with its semi-tropical climate, air conditioning is a boon to comfortable living, and as time goes on more and more homes, hotels, apartments, and commercial and business buildings will install air conditioning equipment. Ground water will be the chief source of supply and if returned to the aquifer and used over again and again no depletion will occur, but if the water is not returned to the aquifer serious consequences may result. On the other hand, a rise in temperature of the ground water through the return of large quantities of heated water may present another problem. In local areas the temperature of ground water has also been changed by the return of hot water from laundries to the aquifer.

The writer in 1941 investigated the case of a well driller who was installing a well for air conditioning a building on West Flagler Street in Miami. The driller, Mr. L. C. Coe, had expected to obtain water of 76 degrees to 77 degrees F., which is normal for ground water in southern Florida, but instead obtained water at 92 degrees F. The source of this heated water was traced to a laundry a few blocks away.

Problems of heated ground water have occurred in some other

parts of the country, notably Long Island, New York (Brashears, 1946, pp. 510-514).

Present Pumpage of Ground Water

Tables II, III, IV, and V attempt to summarize the pumpage of ground water in southern Florida, selecting for comparison a pre-depression year (1929), a depression year (1934), a pre-war year (1939), a war year (1944), and 1945, also a war year in large part. In spite of care in gathering and tabulating these data it is not believed that reliance can be put in some of the figures and therefore, they should be considered only as estimates. Figures on municipal pumpage are not exact because many of the smaller municipalities keep no accurate pumpage data. In the rural and agricultural areas practically no accurate records are available; therefore, the rates of pumpage and total hours of pumpage were estimated. Also, the pumpage of the majority of the industrial plants is largely estimated.

The following tables give a rough estimate of the amount of water used in 1945 by Counties in Southern Florida for municipal, industrial, and rural and irrigation purposes; of the amount of water used by municipalities in certain Counties in 1929, 1934, 1939, 1944, and 1945; of the amount used by industries as compared with total withdrawal in certain localities, and of the amount used by different industries in Miami.

TABLE II

ESTIMATED ANNUAL WITHDRAWAL OF GROUND WATER IN SOUTHERN FLORIDA IN 1945

(In millions of gallons)

County	Municipal requirements	Industrial requirements	Rural and irrigation
Broward	2,040	50	1,340
Charlotte	110	—— 1/	200
Collier	60	20	210
Dade	12,930	4,240	4,140
De Soto	210	—— 1/	220
Indian River	240	5	380
Lee	770	25	700
Martin	160	10	250
Okeechobee	——	5	160
Osceola	245	—— 1/	380
Palm Beach	1,040	700	2,860
St. Lucie	40 2/	30	250

1/ Included in municipal requirements.

2/ Ground water forms only a part of the municipal supply of Ft. Pierce, largest city in St. Lucie County. The major supply is obtained from surface water of the "Savannah."

TABLE III

ESTIMATED MUNICIPAL ANNUAL WITHDRAWAL OF GROUND WATER IN CERTAIN COUNTIES OF SOUTHERN FLORIDA IN SELECTED YEARS

(In millions of gallons)

1929	1934	1939	1944	1945
		Broward County		
380	380	805	2,000	2,040
		Collier County		
60	60	62	60	60
		Dade County		
3,660	4,655	7,480	11,655	12,930
		Indian River County		
44	44	95	240	240
		Lee County		
140	142	304	770	770
		Palm Beach Co. 1/		
645	560	750	812	1,040
		St. Lucie County		
None	None	18	250	260

1/ Disproportionately small totals due to large use of surface water by City of West Palm Beach.

TABLE IV

ESTIMATED ANNUAL WITHDRAWAL OF GROUND WATER IN 1945 WHERE LARGE QUANTITIES ARE USED BY INDUSTRIES

(In millions of gallons)

Location	Withdrawal by industries alone	Total withdrawal in area	Type of aquifer
Greater Miami	4,040	12,275	Non-artesian
Fort Lauderdale	35	2,425	Non-artesian
West Palm Beach 1/	500	660	Non-artesian
Fort Myers	25	735	Artesian and non-artesian

1/ Most of West Palm Beach's supply is surface water obtained from Clear Lake; therefore the amount of ground water used is small in comparison to other cities of southern Florida which use ground water.

TABLE V

ESTIMATED AVERAGE ANNUAL PUMPAGE FROM WELLS IN GREATER MIAMI AREA BY INDUSTRIES

(In millions of gallons)

Industry	No. of plants, 1945	No. of wells in use	1929	1934	1939	1944	1945
Beverages	6	7	8.5	27.0	40.1	70.9	72.3
Dairying	11	23	20.9	40.0	60.0	742.1	806.1
Distilling	1	1	——	16.0	22.9	18.7	18.7
Gas	2	3	157.6	262.8	271.1	432.0	434.9
Ice	7	16	602.2	890.3	951.3	1,530.3	1,700.3
Construction & building	17	26	——	7.7	14.6	25.2	36.3
Laundries	5	7	——	4.9	12.8	23.9	23.9
Air conditioning	3	6	192.4	192.4	367.4	566.3	566.3
Amusement	6	8	——	27.0	27.0	371.9	371.9
Box manufacturing	2	3	——	——	0.6	1.0	1.7
Boat building	5	8	——	——	0.3	0.3	0.6
Miscellaneous	16	22	——	——	1.0	3.6	4.0

Summary and Conclusions

Many municipalities in southern Florida are engaged at present in enlarging and expanding municipal water facilities, which in most places will have to be developed from ground-water sources. In the future it is believed that the expansion of municipal supplies will be even greater than is now evident. As larger and larger quantities of water are required many serious ground water problems concerning the safe yields of the aquifers, with special reference to salt water encroachment, will have to be solved.

In the past small supplies generally were easily developed, but in some places difficulty has been experienced owing to the density and low permeability of the materials comprising the aquifer, or to the existence of salty ground water, even at very shallow depths. In other places salty ground water underlies the uppermost fresh-water aquifers, thus endangering water supplies developed in them. These geological conditions make it imperative that a thorough study of the area by geologists and hydrologists be made before the taxpayer spends large sums of money on developments that may later prove to be useless. Depth, width, areal extent, transmissibility, storage capacities, and the quality of the water in all parts of the aquifers must be ascertained.

In addition to these problems which nature poses are some of man's own making, such as: salt-water encroachment in areas where the fresh-water head has been lowered or upward movement of salt water is taking place owing to pumping; contamination or pollution of ground water by industrial wastes; temperature changes in ground water due to introduction of heated waste water into the aquifer; depletion due to overpumpage; and others.

Fortunately, there are few areas in southern Florida where a plentiful supply of good ground water cannot be developed if the program is intelligently prosecuted. Likewise, there are only a few areas where industrial wastes or overpumpage are dangerous at

present. Where these dangers exist they usually can be corrected if they are intelligently studied and remedial measures are taken.

Salt water encroachment, both from the ocean and from connate water or residual saline bodies, is the most serious problem in the coastal areas. Continued and expanded research should make available to any community in southern Florida data needed to protect its water supply. It has been demonstrated in Dade County that salt-water encroachment from the ocean by way of tidal canals can be largely controlled by use of control works placed as far downstream in the canals as possible. Such installations are especially effective in preventing salt water from flowing inland up tidal canals during times of drouth, and at the same time they maintain a high water table behind the controls, which halts the intrusion of salt water into the aquifer.

The establishment of water preserves in the non-agricultural lands of the Everglades would materially aid in solving some of the salt-water enroachment problems. In these areas water could be stored in times of plentiful rainfall, to seep seaward through the rocks of the Coastal Ridge and thus raise water levels in the coastal zone; and some of the stored water also could be released when needed during times of drouth to replenish over-drained coastal areas or to flush tongues of salty water out of tidal canals.

Our water supply is very much like a bank account—if more is withdrawn than is deposited we eventually go broke. In the ground water aquifers replenishment by rainfall and in flow from contiguous areas must replace losses due to runoff, evapo-transpiration, and pumpage. If these factors are known plans can be made for the effective, continued, and satisfactory use of the aquifers. If, through ignorance or carelessness, the proper handling of this precious heritage is neglected, our water supply in southern Florida can be ruined and lost needlessly.

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PLANNING FOR WILDLIFE PROTECTION IN THE NATURE RESERVES OF SOUTH FLORIDA

Mr. Victor H. Cahalane *

South Florida—the land of sunshine and flowers! South Florida —a region that has many meanings for many people. A domain that is part land, part water. A host of animal and plant communities that have no counterpart elsewhere in the United States.

South Florida, in fact, is formed by plants and animals. The land, slowly creeping out of the sea, is composed of the remains of uncounted generations of living organisms. The flat landscape is lush with riotous vegetation and accented by the "islands" of cypress or cabbage palms. It breathes and lives and moves through an extraordinary assemblage of insects, birds and mammals. Even the waters, both fresh and salt, teem with animal life, ranging from the lowest to the highest types. An exciting Mecca to scientists, tourists and pleasure-seekers.

For centuries after its discovery, South Florida was little disturbed by white man. Remote, mysterious, it was defended by physiographic and climatic features and by numerous classes of its animal inhabitants. Eventually these barriers were overcome.

Commercial exploitation began the inevitable conquest. Some enterprises developed resources of great value. Unfortunately, others resulted only in dissipating basic values of soil and plant and animal life. The heavy attack made upon the bird life by the feather trade proved to be a boomerang. Public indignation was finally aroused against its instigators. While other forms of despoilation may have been just as dangerous, the destruction of birds for their plumage was more obvious. The successful campaign which the American Association of Audubon Societies was able to wage cannot be retold here, but it had the greatest influence on the trend of conservation in South Florida.

Public awareness of the plight of such colonial nesting birds as the egrets, herons, terns and gulls, and pelicans led at once to the reservation of their rookery grounds under Federal protection. By executive proclamation in 1908, President Theodore Roosevelt set aside a number of keys and other islands where plumage hunters had been accustomed to raid important bird colonies. The largest of these refuges was the Key West Bird Reservation, an area of 2,033 acres of water and atolls west of the town of Key West. In 1935, the Dry Tortugas Islands, still farther to the westward, were proclaimed as part of the Fort Jefferson National Monument. These islands are the ONLY nesting grounds of the sooty and noddy terns within the continental United States.

Finally, another group of small islands and parts of islands lying east of Key West were set aside in 1938 as the Great White Heron National Wildlife Refuge. The immediate purpose was to raise the dangerously low level to which this species had been re-

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duced by the 1935 hurricane. However, the White Heron Refuge also shelters numerous other birds, notably the Ward's great blue heron and its hybrid with the great white (the Wurdemann's heron), and the beautiful white crowned-pigeon.

During the establishment of these island refuges, conservationists were worrying about the inroads which drainage, fire and hunting were making on the mainland of South Florida. All of the animals, from the variously colored tree snails to the more spectacular birds and mammals, were disappearing. Every element of the delicately balanced fauna and flora was endangered. Even the soil was being invaded by the sea as fresh water was drained away. Something had to be done to reverse this trend and to assure that the unique natural assets of South Florida would be preserved.

Numerous commissions, groups and individuals set to work. The region was immense and the problem complicated by a vast accumulation of interests and programs. Obviously no one remedy could possibly be applied. One proposal, however, stood forth as the most probable means of perpetuating a majority of the natural resources. This was an Everglades National Park.

The park project was launched in 1929 when Congress committed itself to accept the two-million acre area when the State of Florida should acquire and present the land to the nation. Despite numerous attempts, little progress was discernable for some 15 years. Then, on December 6, 1944, Congress authorized the Secretary of the Interior to accept the lands within a somewhat reduced boundary, subject to gas, oil and mineral reservations, and to protect these lands and their wildlife inhabitants.

As a temporary, interim measure, a national wildlife refuge was established and placed under the administration of the Fish and Wildlife Service. The title to more than half a million acres of state-owned lands has been turned over to the Federal Government, and five hundred thousand dollars of state funds have been alloted for the purchase of additional acreage. The state legislature is being requested to appropriate a further sum of one and one-half million dollars to complete the land acquisition program which will bring together the minimum acreage of 1,355,000 acres necessary to establish the Everglades National Park. It is probable that within a year the major portion of South Florida region will be brought under such strict legal regulation that protection of its wildlife resources will be assured.

At this point, we may well ask: What now is necessary to determine that the expenditure of several million dollars and the efforts of hundreds of workers has been well directed? We shall have reserved for wildlife use a vast area of land and water stretching from the Tamiami Trail to the northern fringe of the Florida Keys and from Royal Palm Hammock to the Dry Tortugas. Can the wildlife here, now make its own way? Does it need only protection from poaching and from unreasonable disturbances by a well meaning public, in order to survive?

If this expanse of parks and refuges were an untouched wilderness, the biologist's answer to these questions would be: "No further steps are necessary. Let it alone and all will be well. This land has

come into being and its plant and animal life has worked out its inter-relationships under the stress of powerful natural forces. Man's attempts to refine the adjustments would produce merely irritations and disturbance. Man knows too little about Nature to improve a wilderness environment."

Unfortunately, South Florida is no longer a complete wilderness in the strict sense. In his blunderings, man has modified portions of the land areas. Drainage and fires have produced far-reaching changes in the vegetation and even in the soil. Nature's balance has been disturbed repeatedly. For instance, the Everglades kite cannot exist without Pomacea snails. These large freshwater snails cannot exist without dampness. When we drain their habitat, we inevitably destroy both species. When we cause severe fires, we do the same thing. Not **one** type is destroyed, but three—the soil, the vegetation, and the dependent inhabitants. If erosion is not too severe, a substitute vegetation may eventually appear. But it will probably be alien to the needs of the original animal residents, and if so, they do not occur again in that region. We have upset Nature's apple cart. No one can estimate the total damage, nor its long endurance.

Numerous species of animals have been depleted in many parts of the Everglades, both on land and in the water. Some of them have been exterminated from certain areas. We must, therefore, try to repair the damage that has been done. Secondly, in the course of our future stewardship, we must try to avoid compounding the mistakes of the past.

In meeting this challenge, the National Park Service and Fish and Wildlife Service must overcome some formidable obstacles. They will require technical skill and funds to correct the damage which has been caused by drainage, fire and erosion. They will need courage and public support to overcome the vested privileges. An even more difficult problem may be those classes of persons who have **fancied** vested privileges. Frequently they are people to whom public property and public interests mean nothing. The commercial plant collector may try to ensure his continued and often illegal gathering of orchids and other plants. Lumber interests may seek to continue cutting of timber. The commercial fisherman may fight measures which are necessary to restore and perpetuate the sponges, shellfish, crustaceans and fish of Florida Bay and Gulf waters. For years, illegal netting and dynamiting of fishing waters have continued. Even if the gun-poacher (who still wears down heavy trails and still brazenly rides around in Glades buggies on the pretense of picknicking) finds no future supporters, the wealthy camera-visitor may be a serious problem. He and his ilk may try to insist on bringing back picture trophies, even at the expense of the well-being of a nesting bird colony. Or the selfish yachtsman may be determined to tramp through delicate coral formations regardless of the lasting destruction that he causes.

There are many other types of problems. The major **environmental** problem on the mainland of South Florida is drainage. Most damage has been done by diversion of normal water flow and seepage. Dikes around agricultural developments to the north of the

Tamiami Trail have shunted eastward great quantities of ground water which formerly moved southwest. As a result, vast areas of the formerly water-soaked Everglades are being converted into parched savannas. Secondly, the rapid drainage of water from the soil has reduced the hydrostatic head and permitted sea water to seep inland for considerable distances.

Drainage is directly responsible for the severity of fire damage. Refuge Manager Beard has reported that many fine hammocks have been burned out in the past eight years, even to the potholes of soil in which they grew. Among the losses are Paradise Key in Royal Palm State Park.

At least 90 per cent of these Everglades fires are human in origin. Caused by fire-hunting, carelessness, and numerous other factors, they can be largely controlled at the source.

In the Dry Tortugas, environmental problems are mostly beyond human control. The islands occasionally are damaged or even destroyed by hurricanes, as was Bird Key in 1935. However, this destruction does not seem to be necessarily permanent. Bird Key appears to be in the process of rebuilding and in the meanwhile the bird colonies have continued to thrive on the neighboring Bush Key.

Coincident with restoration of environment (food and habitat)—is the problem of restoring depleted species of animals. If sufficient seed stock remains, the animals may be expected to increase to their natural limits without further help. Special measures, however, must be taken to ensure that such rare species as the crocodile and alligator, the roseate spoonbill, the Keys white-tail deer and the manatee receive maximum protection and encouragement. Whether the Keys deer can be saved is now uncertain. Timber-cutting of mangroves and lignum-vitae, and hunting has been instrumental in the drastic reduction of this species and of many nesting birds. Since the range of the Keys white-tail is limited to the Florida Keys, a stock is not available elsewhere. It may now be beyond human help.

As stated before, one of the more seriously endangered bird species, the Everglades kite, is dependent on the disappearing Pomacea snails. We can only hope that his mollusc food can be restored, through reversal of the drainage process, in time to be of material assistance to the kite.

The sea turtles, for which the Dry Tortugas were named, have been seriously reduced in numbers. It is essential that the adult animals be protected at all times, and that they be undisturbed during the six to eight week season when the females "haul" ashore to lay their eggs. If necessary, the beaches where the turtles make their nests, at the Tortugas and elsewhere, should be closed to public use during the laying and incubation periods.

Extirpated species should be restored, whenever representatives can be obtained elsewhere, as soon as conditions promise reasonable certainty of survival. West Indian seals **(Monachus tropicalis)**, for example, have been extremely rare in Florida waters during the past century. In previous times, they resorted to the Dry Tortugas for resting and perhaps breeding. The species still persists in the Ba-

hamas and probably in the Tringle Keys off Yucatan. If a few seals can be obtained through the British or Mexican governments, and their safety in the Tortugas region be assured, an attempt should be made to re-establish the species in South Florida waters. This native mammal is a vanishing species. If some individuals can be returned to park and refuge areas, the species will be given an increased chance for survival as a member of the world's fauna.

The coastal region and Florida Bay have been heavily exploited by commercial fishermen. While legitimate fishing will not be hampered, illegal destructive practices such as "stop" netting and dynamiting must cease. The marine resources must be restored and conserved. This will eventually benefit not only sport fishing, which is a major recreational use of South Florida waters, but the commercial fishing industry itself.

Bird nesting colonies and rookeries must be accorded a requisite degree of privacy and protection from the public. During the nesting season, only reputable ornithologists engaged in serious studies should be allowed to enter the colonies. It appears desirable to reduce the banding of birds as it has been practiced at times in the past. The use of aircraft should be regulated in order to minimize disturbances not only of the birds but of the human users of the parks and refuges. Nothing is quite so destructive of the wilderness atmosphere as the roar of low-flying aircraft. Although most birds become surprisingly tolerant of most motor and propellor noise, human nature-enthusiasts do not. To them the atmosphere of quiet and mystery is the most thrilling, intangible characteristic of the South Florida wilderness.

Rare and vanishing plant species which grow only in restricted areas should be given special protection by permitting public visitation only under official surveillance.

Perhaps many of these prohibitions seem to be working against instead of for the general public. On the contrary, park planning and regulation will be designed to permit the general public to use and enjoy the areas to the utmost—consistent with perpetuation of the resources. These resources must be saved for the enjoyment of future generations as well as for the people of the present.

Fortunately adequate examples of Everglades scenery can be made accessible without infringing on the major wilderness. People can be brought to the immediate neighborhood of bird colonies. Here they can watch from the ground or from towers, without disturbing the nurseries or their inhabitants. Visitors can enjoy the marine "gardens" to the fullest extent without impairing the coral or disturbing the brilliant display of marine animals. Properly interpreted by trained, enthusiastic naturalists, the animal and plant life of South Florida will entertain and instruct millions of visitors. It will be a thrilling, unique experience not only for present generations, but for all generations to come.

PROGRESS OF THE UNIT PLAN OF RECLAMATION IN THE EVERGLADES

Mr. Lamar Johnson*

After years of dormancy, Everglades Drainage District is showing signs of life and accepting its responsibilities in the promotion and coordination of Everglades water control activities. This statement is made without criticism of the Boards of Commissioners during those years of inactivity. We realize only too well the legal and financial obstacles that hampered their actions.

Much stress in past years has been given to the need of a plan of water control that would be the solution of water and soil conservation in the Everglades. This District believes that the plan has been developed to a point where the way is now clear for a program of constructive water control improvement. There are those who criticize the plan, saying that it lacks in detail and that too little is known relative to some of the factors involved. I agree with this in part, realizing the need of continued study to develop these details and to provide checks and balances for the main objectives. But I do not agree that we must wait for the dotting of every "eye" and the crossing of every "tee" before we are prepared to begin a constructive program, correcting the many things that are so obviously wrong.

The present plan resulted from action taken by the Soil Science Society of Florida, in 1942. Following the action at this meeting Everglades Drainage District, in August 1943, requested that an advisory committee be formed that included representatives of Federal, State and local agencies.** This Advisory Committee included sixteen technical men, each an authority in his own field. The report that this committee released in 1944 is the nucleus about which subsequent reports have developed a part of the detail.

The most comprehensive treatment of the Everglades problem is contained in the cooperative report of the Soil Conservation Service, U. S. Department of Agriculture and the University of Florida, released in tentative form in 1945 and soon to be released in final form.***

Other reports that have added to the detail of the solution advanced by the Advisory Committee are the two reports released by the Board of Commissioners of Everglades Drainage District and the report of the Water Control Committee of the Palm Beach County Resources Development Board. All of these recent reports are remarkably in agreement in their treatment of the problem. The main objectives of a realistic program of water control and conservation are clearly defined. It is toward the achievement of these objectives as quickly as possible that the District is now working.

As is so often the case, when the plan is ready the funds are not. Legislative restrictions prevent the use of acreage tax money for rehabilitation or construction. The only funds available for this type

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of work, at present, are the proceeds of the one-half mill ad valorem tax levied for administration purposes. The present Board has not hesitated to use from this fund for constructive work to the extent the monies were available.

These funds have been largely appropriated for use in cooperation with other agencies, or groups of landowners, to perform specific projects of construction or maintenance. This spirit of cooperation on the part of the landowners is very encouraging and expresses a confidence in the administration of Everglades Drainage District affairs that was so noticeably absent during the years of legal and financial entanglement.

The Board has also appropriated funds to carry on a program of hyacinth eradication over more than 200 miles of the District's canal system. The success of this program is being watched throughout the South. Dr. Allison will give you detailed information on the method of eradication later this afternoon.

The Board of Commissioners of Everglades Drainage District has not waited for monies to become available for work projects to begin its most constructive work. In conformity with the general plan, the Board has indicated the service-areas of each of the existing canals and the service to be provided to most of the other agricultural lands of the upper 'Glades. The Board has created three conservation areas embracing over one-half million acres of lands that have little or no agricultural value. These conservation areas, I believe, will prove to have as great an effect on the economic future of South Florida as the construction of the arterial canal system.

The primary purpose for the creation of these conservation areas is their relation to water control. The Palm Beach and Broward areas are effective in retarding runoff from large areas of idle land at times when the canal's capacity is needed exclusively for service to farming operations. The Dade-Broward area, when placed in operation, will tend to stabilize the ground water levels in the lower coastal agricultural lands and in the Everglades National Park. All of these conservation areas by their operation will improve coastal ground water tables generally, to the benefit of agricultural and domestic water supplies. A moderation in extremes of winter temperatures will certainly result to lands within the range of influence of the wet regions.

The Palm Beach County conservation area is substantially in full operation at present. The March rains recharged the area to near maximum levels. It is proposed that this particular conservation area be turned over to the Federal Fish and Wildlife Service for control and operation. Everglades Drainage District will continue to control the water stage of the area within maximum and minimum stages established by agreement with the Fish and Wildlife Service.

In the Broward County conservation area, a levee on the east boundary, along Range Line 40-41, is needed to make its operation effective. This levee will be constructed as rapidly as possible as a cooperative project of Everglades Drainage District and Broward Drainage District. In fact, surveys were begun Monday and a dragline is now at work on the construction. The control necessary to regulate the waters within this area was constructed a year ago by

Everglades Drainage District with funds furnished by Broward Drainage District, Broward County and the City of Fort Lauderdale. Recharge of this area from the Hillsboro Canal is feasible at such time when that canal's channel has been improved to make waters from Lake Okeechobee available.

Operation of the most recently created of the three conservation areas, the Dade-Broward Area, will not be fully possible until a levee is constructed along Range Line 38-39 and controls are constructed in the Tamiami Trail openings. Everglades Drainage District has just completed a survey along the part of this proposed levee that forms a highway link between Krome Avenue and Road 25 (Old Road 26-A). In return for the assistance given by the District in making the survey and supplying the right of way, the Road Department has agreed to construct the road borrow pit in such a manner that it will serve as a part of the recharge channel necessary in connection with the operation of this area.

Improvement to the channels and controls of the North New River and upper Miami Canals would make partial recharge of this area feasible. A movement of a part of the flood waters of the North New River Canal to the southward would help solve the flood problem along this canal. Boating, bathing and fishing in the Dade-Broward area are still a long way off, but we do believe that the time is not too far distant when we can forget the threat of annual peat fires there.

So, you see, the Board of Commissioners of Everglades Drainage District is finding ways to do constructive work with very little money. They are actively laying the ground work that will facilitate the execution of a beneficial program when funds are available—from whatever source. The District is asking for authority at the coming session of the State Legislature to levy an equitable maintenance tax on lands actually benefitted for the maintenance and rehabilitation of the present system. Funds will be made available for the necessary new construction that will protect the natural resources of soil and water and provide additional service to new lands as they are developed. I have faith in that.

I believe we have had enough of talk, enough of plans, and enough of passing the buck and letting George do it. The job is ready to be tackled by we people of the 'Glades and the people of the State. It is our job and we will reap the benefits of a good job, well done. It is not too late, if we hurry.

HYACINTH CONTROL THROUGH THE USE OF 2,4-DICHLOROPHENOXYACETIC ACID IN DIFFERENT FORMS AND AT VARIOUS RATES OF APPLICATION

Mr. Charles C. Seale and Dr. R. V. Allison*

Introduction.—The water hyacinth, **Eichornia crassipes** Solms., is a vigorous growing perennial plant, which inhabits areas of fresh or slightly brackish water. It propagates itself primarily by vegetative means, but also produces viable seed, which germinate under favorable conditions.

This plant is not entirely winter hardy, but can survive intermittent periods of frost.

The exact date of the introduction of the water hyacinth into the United States is not definitely known, but early records indicate that is was in Louisiana as early as 1884. From that time onward, it appears to have spread into several neighboring states, including Florida, where suitable environmental conditions existed for its growth. It seems quite likely that this spread was greatly accelerated by human agencies on account of the ornamental characteristics of the plant. At the present time water hyacinths are found in most of the natural and artificial waters of Florida. In the northern part of the state it is a troublesome pest, but it is in the south of Florida where it does the greatest amount of damage.

In this area it has invaded the entire canal system of the Everglades Drainage District, and now impedes the free movement of both drainage and irrigation water, thus causing considerable economic losses to agriculture in this important section.

In badly infested areas, the density of the hyacinth cover in the canals is frequently as great as 200,000 plants per acre. Under such conditions of surface growth Clayton and Neller (2) reported that according to standard plan measurements, the discharge capacity of the main canals was reduced by approximately 50 percent.

It is a generally accepted fact that for successful crop production in the Everglades it is absolutely necessary to be able to control water levels in the land within certain narrow limits. During the rainy season, this generally cannot be accomplished, owing to the slow movement of water through the drainage system as the result of hyacinth obstruction, and consequently heavy crop losses are frequently sustained from the drowning out of crops. Under such conditions pumping costs also are increased for the following reasons:

(1). The necessity of pumping water against a greater head than should otherwise be necessary.

(2). The greater difficulty of keeping the pump screen clear.

During the dry season, further losses of a different nature are

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sustained. At such time, large volumes of water badly needed for maintaining satisfactory water levels, are lost by transpiration from the dense hyacinth cover. These transpiration losses have been estimated to be about 2 to 2½ times as great as those resulting from open water surfaces.

When all the above factors are considered from a water and soil conservation point of view, it will be seen that the water hyacinth is responsible for a wide variety of losses of very great magnitude to agricultural and other interests, and that this area would be well rid of the obnoxious pest.

It is possible that water hyacinths may have some potential value for economc utilization in the future, but it must be clearly borne in mind that this is of secondary importance when compared with the pressing and urgent necessity for their complete eradication from the drainage system of the Everglades region of Florida.

Control and Eradication

(1) Mechanical Methods.—In the past attempts have been made to use mechanical methods for the control and eradication of water hyacinths in the Everglades region of Florida.

A few farmers have used draglines, especially on smaller farm canals, with some success, but this procedure, which is estimated at over $100 per mile, is too expensive for practical large scale operation. Also the U. S. Engineers have developed a saw-boat which operates quite satisfactorily. This machine has a place in a certain phase of the control work, but cannot be considered as suitable alone for total eradication purposes.

(2) Biological Methods.—Water hyacinths appear to be comparatively free from any very destructive insect pests or diseases.

The plants are often attacked by unidentified species of red spider and rat-tail maggot, but the damage done appears to be slight and the vegetative vigor of the plant is not much impaired.

According to Evans (3), an unidentified disease attacking the roots of hyacinths was observed in 1939 by the District Engineer, U. S. Engineer Office, Jacksonville on plants growing in the lower Withlacoochee river. No success, however, attended an effort to transmit this disease to healthy plants by the transplanting of infected material.

Thus biological methods of control do not appear to offer any very hopeful solution to the problem at the present time, and are merely mentioned as a matter of passing interest.

(3) Chemical Methods.

(a) Early Attempts.—Since about 1898 several attempts have been made by the U. S. Army Engineers in Florida to control water hyacinths by chemical means. Many materials such as kerosene and crude oils, hydrochloric, sulphuric and carbolic acids were tried, as well as more toxic chemicals such as the arsenites of lime and soda, copper sulphate and potassium bichromate. The former types gave poor results and the latter, although they produce better herbicidal effects, were considered unsatisfactory because of their toxicity to livestock, which might feed upon the sprayed plant material.

The results of these early trials caused their investigators to conclude that the only solution lay in methods of mechanical control.

(b) More Recent Trials—The work of Kraus and Mitchell (6) first demonstrated the selective herbicidal properties of several growth-regulating substances including 2, 4-dichlorophenoxyacetic acid, otherwise known as 2, 4-D. Since that time an increasing amount of attention has been paid to their use as weed killers. This hormone-like chemical substance possesses many desirable characteristics which make it well suited as a herbicide. Important among them is the fact that it is non-toxic to humans and livestock; bearing this out, Mitchell et. al. (6) observed no harmful effects from the daily feeding of a cow 5.5 grams of purified 2,4-D for a period of 108 days. Moreover, 2,4-D is non-corrosive to spray equipment, causes no irritation to the skin, and is neither explosive nor inflammable.

During the spring of 1945 some very preliminary trials with 2,4-D on water hyacinths at the Everglades Experiment Station showed it to be highly effective against this pest. These early trials, as well as later and more systematic studies, were made chiefly on the dense growth of this plant then covering the entire surface of the Hillsboro canal, which flows past the Experiment Station. The later and more detailed studies were started in March 1946, and were followed shortly by an extensive eradication program by the Chief Engineer of the Everglades Drainage District, which extended on through the summer and well into the winter of that year. The late phase of the operation during the autumn and early winter of that year was made possible only by the unusually warm, frost-free conditions that prevailed until the early part of February 1947.

In the meantime Hilderbrand (4) did some very careful investigational work along the same lines in the Tampa area of Florida in 1945, and reported the successful use of 2,4-D for the control of water hyacinths in 1946.

The type of experimental work carried out at the Everglades Experiment Station and some of the results obtained are given in detail below.

(1) Dusting Experiments with 2,4-D

(a) Experimental Procedure.—More or less contemporaneously with the organization of the spraying studies, two experiments involving the application of 2,4-D in dust form were laid out in March and April of 1946 on the Hillsboro Canal at the Everglades Experiment Station. In these studies, the herbicidal effects of the sodium and ammonium salts, and the methyl ester of 2,4-D were compared.

Rates of application ranged from 0.2 to 1.6 pounds of 2,4-D acid equivalent per acre. Talc and collodial phosphate were used with the 2,4-D materials as fillers, in such proportions as to build the total dust application up to 30 pounds per acre.

The plots were laid out as 5-foot squares, and the dust treatments were applied with a hand dust gun, model Duster Billows No. 191. In order to obtain a sharp plot definition and also to reduce the loss of dust by wind currents, plots were enclosed at the time of dusting with a portable frame having light covered sides. This frame was the same size as the plots, and about 30 inches in height.

(b) Experimental Results.—The herbicidal effects of the dust treatments in these experiments were definitely inferior to the spray

treatments, of similar rate of 2,4-D application, which will be outlined further on in this paper. These effects were evaluated by visual observations only and no counts were made of the death of the growing points or the condition of the rhizomes.

The characteristic symptoms of 2,4-D were much slower in making their appearance, and, more important still, none of the treatments produced a satisfactory kill. Although the sodium salt of 2,4-D applied at the rate of 1.6 pounds of its acid equivalent per acre gave the best results, this was by no means satisfactory, especially when compared with the results of the liquid spray.

It should be noted that treatments receiving colloidal phosphate as a filler were better than those with talc. This might be due to the greater adhesive properties of the former.

The writers do not consider the results of these dust trials by any means final and conclusive, and believe that it might be desirable to try further applications of 2,4-D dusts, including impregnation with various quantities of oil.

(2) Spraying Experiments with Aqueous Solutions of 2,4-D Applied With Ground Equipment.

(a) Experimental Procedure.—In March, 1946, and January and March, 1947, three experiments were laid out by the writers on the dense hyacinth mat covering the Hillsboro Canal in front of the Everglades Experiment Station.

In these experiments different chemical forms of 2,4-D including the sodium, ammonium and potassium salts, three ester forms, and two amine salts were compared in aqueous solution at rates of application ranging from 0.4 to 2.0 pounds of 2,4-D acid equivalent per acre.

Plots were sprayed in 1946 with a Hudson sprayer, and in 1947 with a Mohawk hand spray gun. The latter proved to be more convenient for this type of work.

Size of plots ranged from 1-100 to 1-160 acres in area, and total spray application from 100 to 200 gallons per acre.

General visual observations were made on the herbicidal effects of the treatments, but the principal criteria used for their evaluation was the condition of the growing points and rhizomes of the plants two to four weeks after spraying. For this purpose, representative samples of plants were taken from the plots, sectioned and examined for death of the growing points and decomposition of the rhizomes. The former condition was generally indicated, among other symptoms, by the disappearance of the pink color normally associated with the surrounding tissue.

(b) Experimental Results.—Certain very general aspects of the experimental results obtained in 1946 have already been presented by Allison (1), but the detailed data for the two years of experimentation is given below.

The herbicidal effects of the aqueous spray treatments of different chemical forms of 2,4-D can best be indicated by the condition of the growing points and rhizomes after spraying. These data are presented in Table 1.

TABLE 1.—EFFECT OF DIFFERENT CHEMICAL FORMS AND RATES OF 2,4-D APPLICATION ON GROWING POINTS AND RHIZOMES OF WATER PLANTS.

Chemical Form of 2,4-D	% Growing Points Dead					% Rhizomes Decomposing				
	Pounds of 2,4-D Acid Equivalent per Acre					Pounds of 2,4-D Acid Equivalent per Acre				
	0.4	0.8	1.0	1.6	2.0	0.4	0.8	1.0	1.6	2.0
Butoxyethanol ester - Type A	-	-	72	89	94	-	-	59	68	80
" " - Type B	-	-	-	-	85	-	-	-	-	80
Butoxyethyl ester	-	-	92	-	100	-	-	67	-	84
Butyl ester - Type A	-	-	78	80	100	-	-	61	64	93
" " - Type B	-	-	-	-	95	-	-	-	-	90
Triethanol amine salt - Type A	-	-	83	85	96	-	-	69	73	83
" " " - Type B	-	-	75	-	85	-	-	48	-	85
Alkanol amine salt - Type A	-	-	-	89	-	-	-	-	82	-
" " " - Type B	-	-	84	-	92	-	-	70	-	83
Sodium salt - Type A	34	42	62	80	100	21	37	50	54	86
" " - Type B	-	-	-	70	-	-	-	-	60	-
" " - Type C	-	-	71	-	93	-	-	61	-	85
Ammonium salt	60	70	73	84	97	16	29	50	65	87
Potassium salt	-	-	74	-	96	-	-	57	-	81
Unknown	40	48	-	69	-	22	32	-	47	-
Unknown	38	52	-	74	-	26	33	-	38	-
Unknown	30	62	-	71	-	12	29	-	38	-
Averages	41	61	77	79	95	19	34	59	58	85

In order to indicate more clearly the differences in the herbicidal effects of the principal chemical forms of 2,4-D used in these experiments, the above data is re-arranged in Table 2 below:

TABLE 2.--EFFECT OF PRINCIPAL CHEMICAL FORMS OF 2,4-D.

Chemical Form of 2,4-D	% Growing Points Dead					% Rhizomes Decomposing				
	Pounds 2,4-D Acid Equivalent per Acre					Pounds 2,4-D Acid Equivalent per Acre				
	0.4	0.8	1.0	1.6	2.0	0.4	0.8	1.0	1.6	2.0
Esters	-	-	83	85	97	-	-	62	66	85
Amine salts	-	-	81	87	91	-	-	62	77	84
Inorganic salts	46	61	70	78	97	19	33	55	56	85

It should be noted that although the results in Tables 1 and 2 do not represent the exact mortality of the plants at the final stage, nevertheless they should provide a fairly reliable index from which this can be estimated. In most cases when the growing points are dead, it is not very likely that many of the plants will continue to live, especially if they are young and have poorly developed rhizomes. Also when the rhizomes are showing signs of decomposition, it is thought that the chances of the survival of the plants are slight. Consequently the figures for actual mortality are likely to be somewhere between the two sets of data.

An inspection of the data in Tables 1 and 2 reveals the following points: (1) the esters and the amine salts of 2,4-D produce the strongest herbicidal effects, and both of these chemical forms appeared to be better than the inorganic (sodium, ammonium and potassium) salts. In this connection, it seems worth noting that in summarizing the Report of the Policy Committee on Herbicides of the North Central Weed Control Conference, Willard (7) reports that although there are large and obvious differences in the effectiveness

of different 2,4-D formulations, in general it appears that those containing 2,4-D esters have been more effective under difficult conditions and on resistant plants than other chemical types.

(2) Good herbicidal results were obtained with applications of 1.6 and 2.0 pounds of 2,4-D acid equivalent per acre with the more active chemical forms. However, it is obvious that the lower rates of application, 0.8 and 0.4 pounds 2,4-D acid equivalent respectively per acre were not sufficient to produce satisfactory results, and later observations indicated that plots receiving these rates of treatment eventually recovered. Evans (3) who also worked on hyacinth control in this area during the summer and autumn of 1946 independently drew somewhat similar conclusions. In one of his experiments, he applied treatments ranging from 0.7 to 8.0 pounds 2,4-D acid equivalent per acre, and states "it would appear that the most economical treatment lies in the range of 1.3 to 2.0 pounds per acre".

It also is of interest to note the sequence of herbicidal effects with the better types of spray treatments. Within 1 to 2 days after spraying a pronounced condition of epinasty was noticed. A strong wilt was observed in about 7 days, and death of the plant in 4 to 5 weeks time. Complete sinking of the dead plants was usually delayed until about 6 to 8 weeks after spraying, depending on rate of treatment and also to some extent on season.

(3) Spraying 2,4-D by Airplane.—On the basis of the encouraging results obtained from the 2,4-D experiments with ground spraying equipment enumerated in the previous section, it was decided to investigate the possibilities of spraying 2,4-D by airplane for the control of water hyacinths.

After several preliminary trials were carried out under close supervision and it was proven that this method of application was entirely practicable, the Everglades Drainage Board decided to undertake a large scale spraying program to cover more than 100 miles of some of the principal arterial canals in the Everglades drainage system. The flying in all these tests was done under contract with Air Spray Inc., and the plane used was an N3N model biplane fitted with a 50 gallon tank and special type of spray rig. When hyacinths were being sprayed the plane was flown at an altitude of about 10 feet above the surface of the canals in order to obtain proper placement of the spray. Under these conditions an effective spray swath of about 60 feet was obtained.

In the early trials, the triethanolamine salt of 2,4-D was used at the rate of about 2 quarts diluted to 2 gallons with water per acre; this was equivalent to about 2 pounds of actual 2,4-D acid. This treatment, however, did not give results comparable to those obtained with ground equipment using the same amount of chemical in about 200 gallons of water, and this might have been due to the high vaporization rate of the water fraction of the spray when applied in such a small volume.

In order to overcome this difficulty No. 2 diesel oil was substituted as a carrier for the 2,4-D. This material was chosen chiefly for its comparative cheapness and ready availability. Also the oil-miscible butyl ester form of 2,4-D was used instead of the triethanolamine formulation, which will not mix readily with the oil carrier.

After several trials it was finally decided to use a 40 percent formulation of the butyl ester form of 2,4-D mixed with No. 2 diesel oil in the ratio of about 1 to 4.5 respectively. This mixture was then applied at the rate of 2 gallons per acre, and represented a treatment of approximately 1 pound of 2,4-D acid equivalent per acre. The results obtained with this treatment have been very satisfactory, and are definitely better than those with a similar quantity of 2,4-D applied in much larger volumes of aqueous sprays.

In 1946 about 100 miles of some of the principal arterial canals were sprayed by plane with the above mentioned 2,4-D and diesel oil mixture. Two spray applications were generally applied. The first application killed a large percentage of the plants, and the second accounted for the survivors, which had consolidated into "jams" separated by stretches of open water.

The effectiveness of these large scale treatments can best be indicated by making a comparison of the existing coverage of water hyacinths on the sprayed areas with the condition that prevailed before spraying, when there was a dense cover over practically the entire surface of all the canals.

The present position obtained from a recent survey in the latter part of March 1947 is presented in Table 3 below:

TABLE 3—PERCENT HYACINTH COVERAGE

Canal	Covered with Hyacinths	Open Water
West Palm Beach	5	95
Cross State	70	30
Hillsboro	48	52
North New River	45	55
Weighted Average	38	62

It will be seen from the above data that spraying with 2,4-D has been responsible for the removal of approximately 62 percent of the hyacinth cover, when all the sprayed areas are considered as a whole.

For a start this is quite encouraging, and it is thought that even better results might have been obtained if it had not been for the following:

(1) the herbicidal effects of the spraying in 1946, which was done mainly during the summer months was greatly reduced by the heavy rains which frequently fell a short time after spraying.

(2) there was a rapid "regrowth" of hyacinths, especially during the winter season of 1946-47, when little or no spraying was done within the farming areas for fear of damage to vegetable crops. It is believed that this "regrowth" is due to the following factors:

(a) the recovery of plants not receiving a lethal application of 2,4-D.

(b) fresh growth developing from seedlings, which have been seen germinating on the decaying mat of dead plants after spraying.

When considering this condition of regrowth it is of interest

to note that King (5) claims the treatment of hyacinths with 2,4-D, especially at a particular phase of their development, tends to stimulate basal bud development, and states that this can be corrected by fortifying the 2,4-D treatments with certain other chemical substances.

It should be borne in mind that the methods used in the airplane spray trials with 2,4-D previously enumerated must still be considered as experimental and tentative. As the eradication program proceeds it may be necessary to introduce certain modifications, even though the economy of the operations to date are beyond question when compared with the cost of mechanical means of control.

When the greater part of the existing hyacinth growth on the treated areas has been satisfactorily removed by the present method of airplane spraying with 2,4-D, it would be more economical to make a thorough clean-up of isolated clumps and small areas of plants fringing the canal banks by spraying 2,4-D with suitable equipment by boat. This method could also be used as the basis of a regular patrol system which will have to be initiated in order to prevent the re-establishment of this troublesome plant pest.

SUMMARY

1. The water hyacinth, **Eichornia crassipes** Solms., is a troublesome pest in the natural and artificial waterways of Florida.

2. It has invaded the entire canal system of the Everglades drainage district where it now greatly hampers water control measures, thus causing heavy losses to agriculture and other interests in this important farming area.

3. The possible economic utilization of the plant definitely appears to be of secondary importance when compared with the urgent necessity for its eradication.

4. Of all the methods of control, those by chemical means employing the use of 2,4-dichlorophenoxyacetic acid, in one form or another, are the most promising yet tried. Mechanical methods tend to be too expensive, and biological methods of control appear to offer little promise of success.

5. Since March 1946 an organized attempt has been made by the Everglades Experiment Station and the Everglades Drainage Board to control water hyacinths by chemical means with the use of 2,4-D.

6. In 1946-47 experiments were carried out by the Everglades Experiment Station using various chemical forms of 2,4-D applied at rates ranging from 0.2 to 2.0 pounds 2,4-D acid equivalent per acre. The results of these experiments indicate that:

(a) Spray treatments with 2,4-D were far superior to dust treatment.

(b) Good herbicidal effects were obtained with aqueous spray applications of the ester and amine forms of 2,4-D applied at the rate of 1.6 to 2.0 pounds of 2,4-D acid equivalent per acre.

7. As a result of these encouraging preliminary trials, airplane spraying with 2,4-D at low volume rate was tried, and early trials indicated that the triethanolamine salt of 2,4-D in 2 gallons of aqueous solution did not give very satisfactory results. This method was then modified by substituting No. 2 diesel oil for water as a carrier, and by using the butyl ester form of 2,4-D, which is oil mis-

cible. This latter treatment has proven to be very satisfactory, giving better results than the same rate of 2,4-D application in aqueous sprays, and has been used by the Everglades Drainage Board for the large scale spraying by airplane of about 100 miles of the arterial canals in the Everglades region of Florida in 1946.

8. The results of these large-scale spraying trials indicate that approximately 62 percent of the original dense hyacinth cover has been removed by the 2,4-D treatment. The reasons for not obtaining even greater success are cited.

9. The methods employed in these airplane trials must still be considered as tentative and experimental, and might have to be modified as the program of eradicating hyacinths proceeds.

10. For the final clean-up measures, the spraying of 2,4-D by boat appears to be more economical. Moreover, this method could also be used as the basis of a regular patrol system in order to prevent the re-establishment of the hyacinth plant.

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Standard Agricultural Chemicals, Inc., and
The United States Rubber Co.

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THE NEED FOR MORE DETAILED CLIMATOLOGICAL STUDIES IN SOUTH FLORIDA

Mr. J. W. Milligan*

Good climate and successful farming are synonymous. The weather affects the farmer every day and is not just something the farmer accepts passively. He constantly works to take advantage of favorable elements and works even harder in an effort to counteract unfavorable ones. In fact, much of our modern agricultural science has a direct bearing on his efforts in this and other fields.

Many of our comparisons in every day life are based on the size or immensity of something. As far as climatology is concerned, however, this aspect is only relative. For example, to a geologist a long-time trend in climatic change might occupy a million years or so. To a climatologist, especially one who is dealing with our present instrumental period, a long-time trend might be a matter of half a century to several centuries. For local climatological studies, short-time fluctuations might involve only a small number of years yet be just as valuable.

In the instance of the grower, however, who is chiefly concerned with agriculture, the interest chiefly centers about the question of variation from one year to the next. It is with this point of view in mind that the climatologist is constantly working with short-time fluctuations dealing with some specific problem.

The purpose of this paper is to present a few general climatological studies that have been carried on in the past by the writer especially as they deal with the weather of South Florida; also to point out the need for further studies of this nature in order to properly evaluate our local climatic changes.

While the temperature chart of Figure 1 is based only on the winter periods 1924-1944 and thus represents only a relatively short period of time, its many fluctuations reveal certain climatic factors and afford a helpful basis for study of causal relationships in connection therewith.

Thus quite a noticeable feature of these short-time fluctuations are the numerous cold periods beginning in November or December and continuing through early January. Ordinarily one would presume that South Florida would continue to get progressively colder as the winter season advances with the greater number of freezes confined to late January and early February. However, an examination of the trend for the past twenty years (Fig.1) would seem to indicate quite definitely that this is not the case. Consideration must be given, of course, to the prospect that the above trend may change notably in the next twenty years. On the basis of the present record, however, it seems an undeniable fact that our cold periods in South Florida during the early part of the winter are very closely associated with the type of weather occurring over the Great Basin area (the region over the Rocky mountains in which Utah is roughly the center). The following charts are offered as a possible explanation of this

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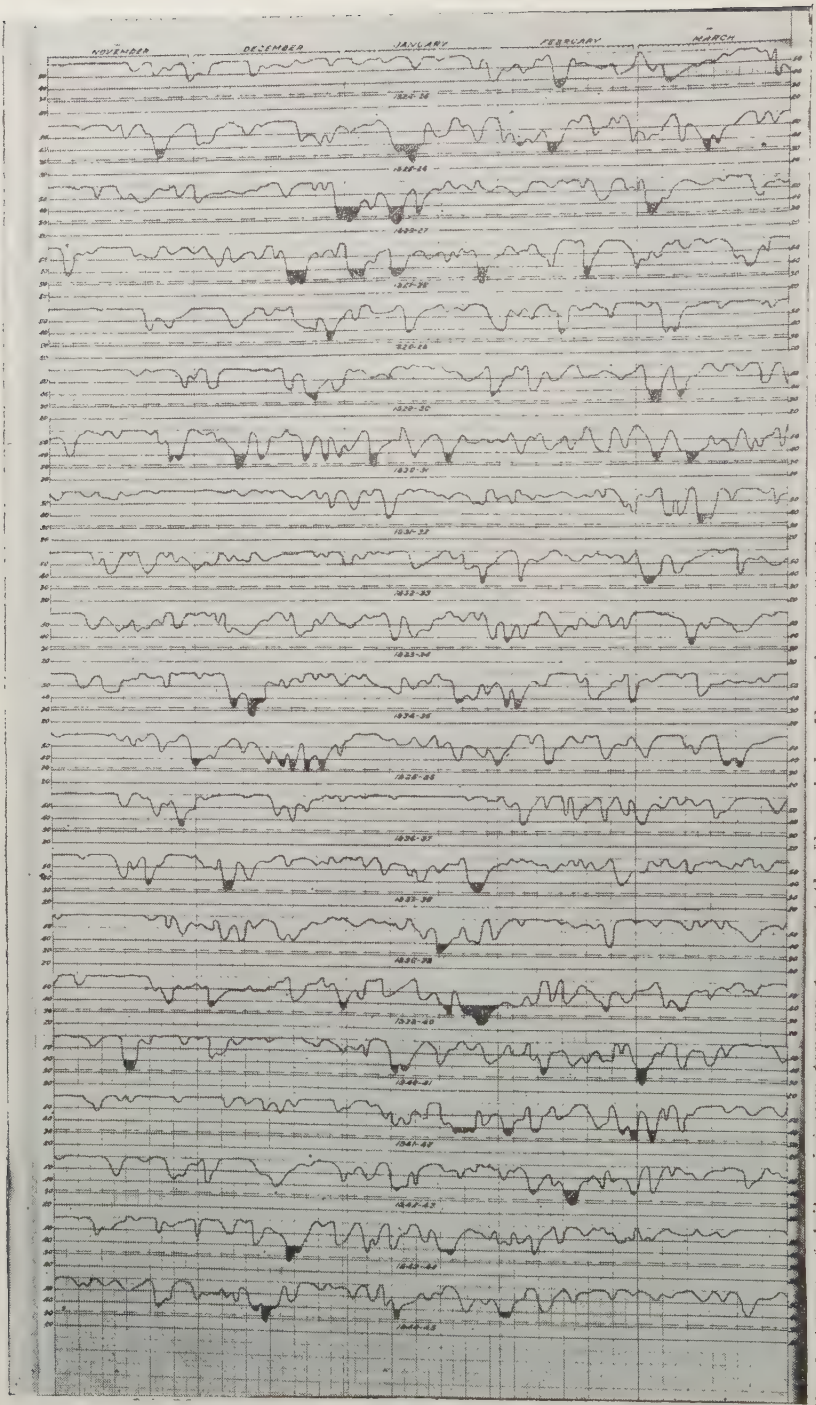

Fig. 1. Chart of daily minimum temperatures at the Everglades Experiment Station, Sec. 3, T44S R37E, Palm Beach County, Fla.

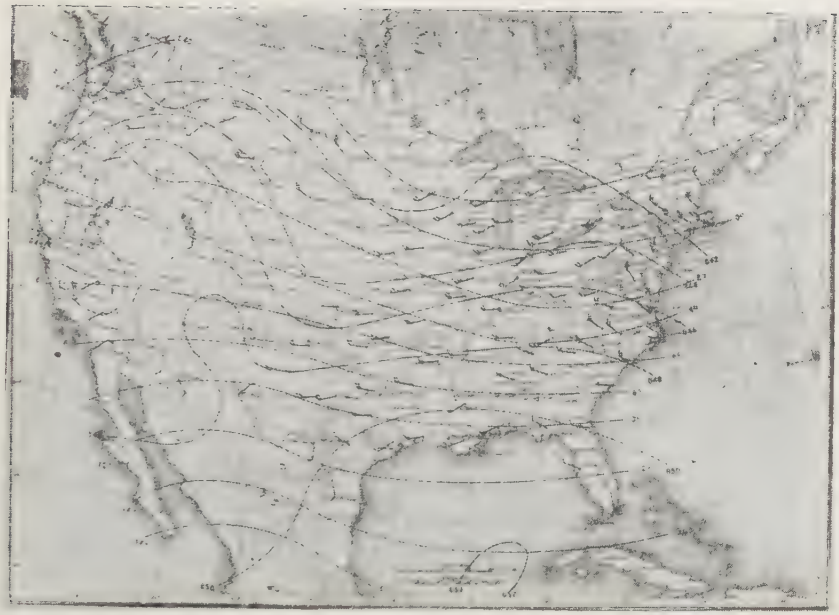

Fig. 2 Upper air (5000 ft.) chart of pressure and resultant winds over the United States for November, 1944, as published by the U. S. Weather Bureau in its Monthly Weather Review.

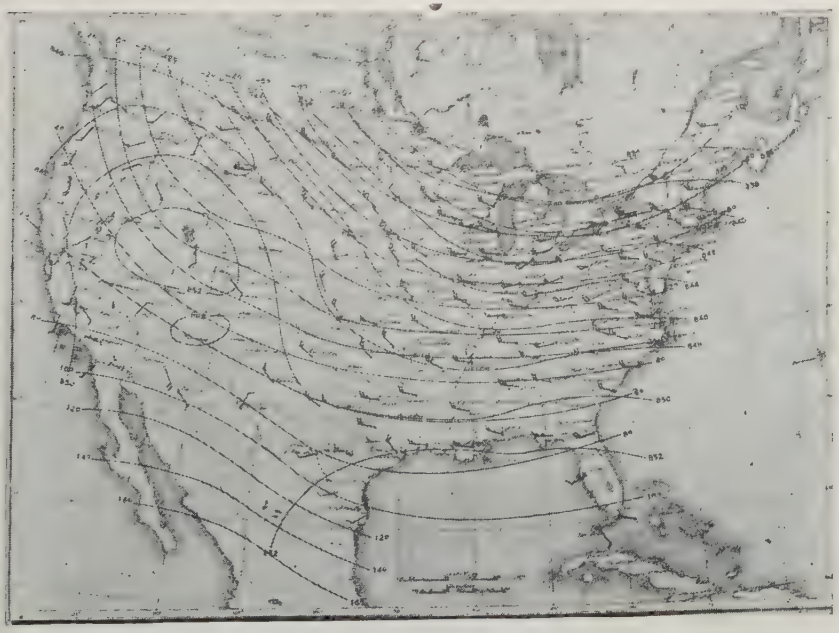

Fig. 3. Upper air (5000 ft.) chart of pressure and resultant winds over the United States for December, 1944, as published by the U. S. Weather Bureau in its Monthly Weather Review.

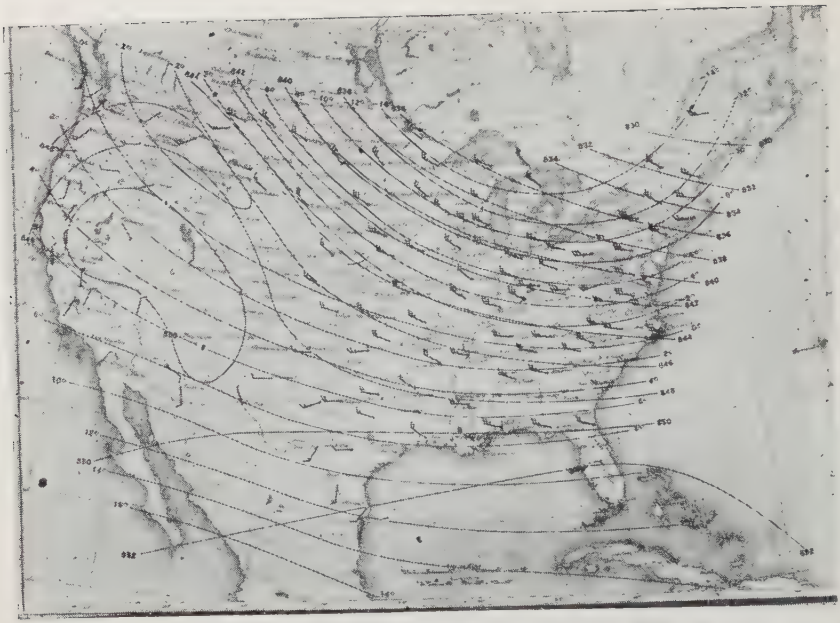

Fig. 4. Upper air (5000 ft.) chart of pressure and resultant winds over the United States for January, 1945, as published by the U. S. Weather Bureau in its Monthly Weather Review.

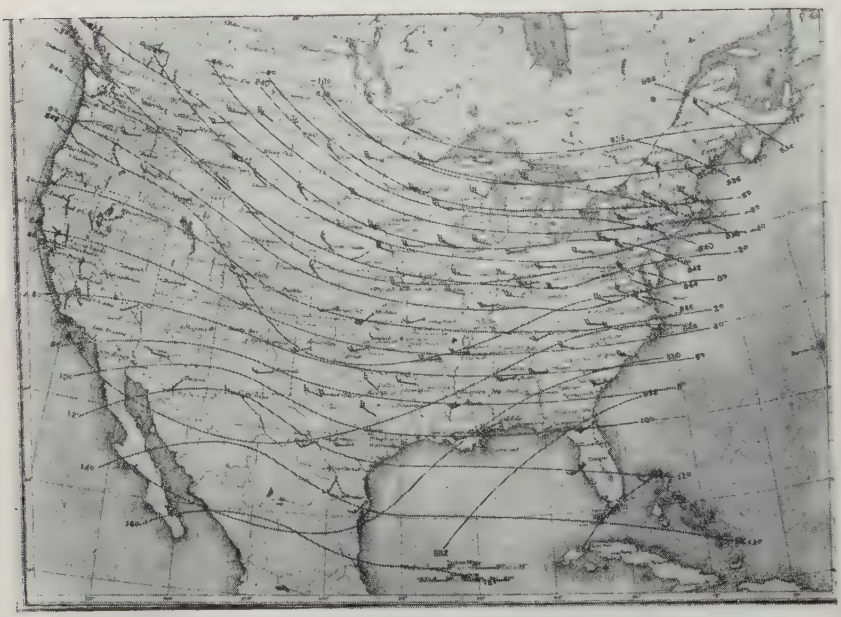

Fig. 5. Upper air (5000 ft.) chart of pressure and resultant winds over the United States for February, 1945, as published by the U. S. Weather Bureau in its Monthly Weather Review.

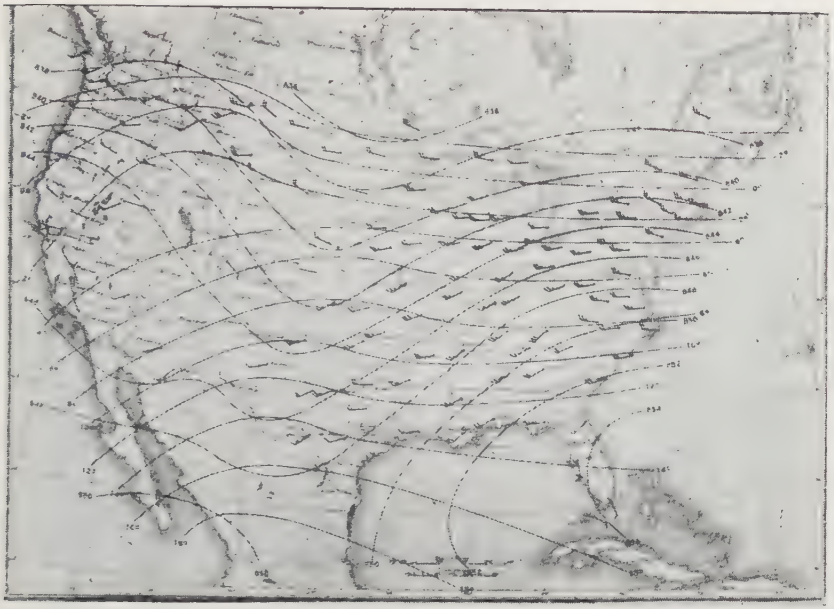

Fig. 6. Upper air (5000 ft.) chart of pressure and resultant winds over the United States for March, 1945, as published by the U. S. Weather Bureau in its Monthly Weather Review.

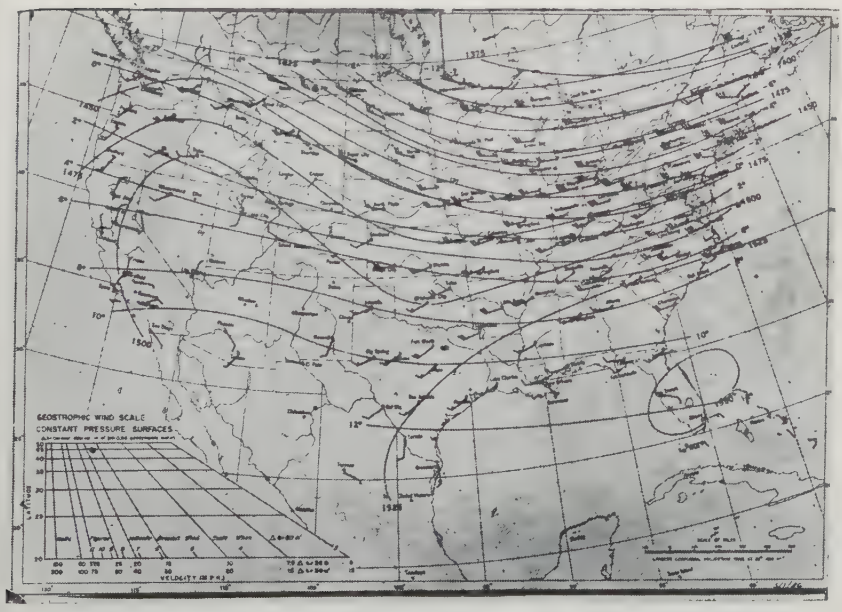

Fig. 7. Upper air (5060 ft.) chart of pressure and resultant winds over the United States for December, 1946, as published by the U. S. Weather Bureau in its Monthly Weather Review.

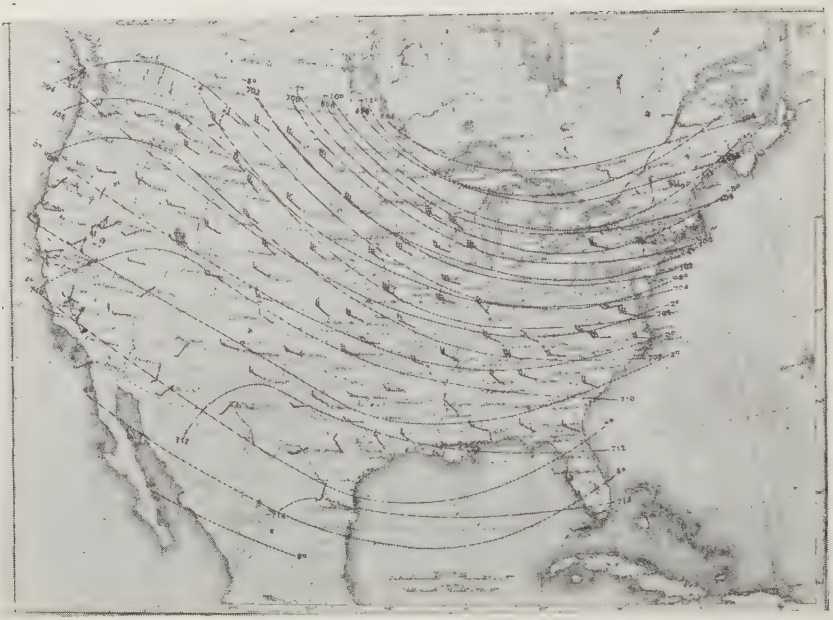

Fig. 8. Upper air (5000 ft.) chart of pressure and resultant winds over the United States for November, 1943, as published by the U. S. Weather Bureau in its Monthly Weather Review.

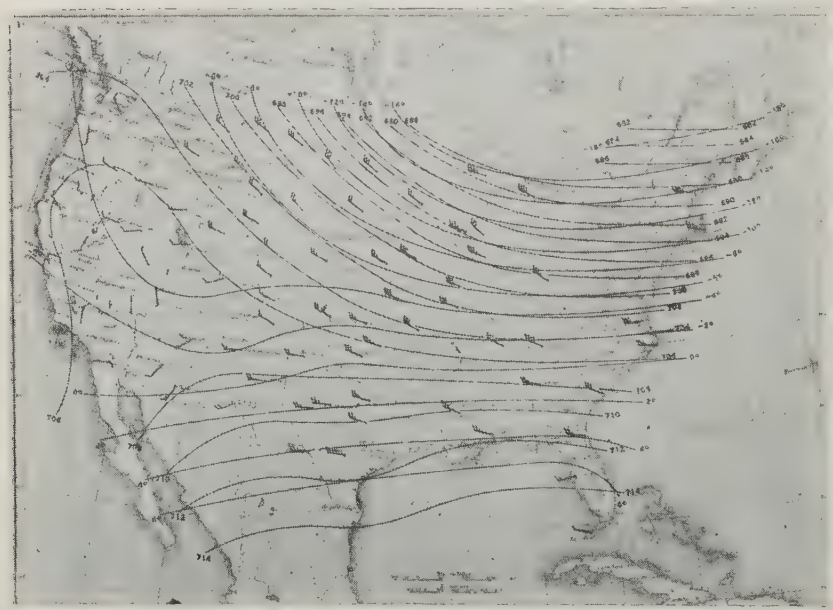

Fig. 9. Upper air (5000 ft.) chart of pressure and resultant winds over the United States for December, 1943, as published by the U. S. Weather Bureau in its Monthly Weather Review.

trend which has been quite evident during the period under study. (Figs. 2-9).

The writer's theory as to why this is true is based largely on the observation that the build-up of pressure in the Great Basin area, and consequent northward extension, changes the wind streams with a subsequent lowering of pressure over the Florida coast. This condition acts as a doming and tilting effect in which the dome acts as a slide from which the continental cold air masses, centered in the middle and far northwest, are transported by deep northwest winds aloft to the Florida Straits.

An examination of the eight 5000-ft. level charts (Figs. 2 to 9) (pressure lines in black and resultant winds indicated by arrows) shows the change from a warm, southwesterly air movement in early November, 1944, (Fig. 2) to a cold, northwesterly current flowing from the Mississippi Valley into southern Florida during December, 1944 and January, 1945 (Figs. 3 and 4). The change back to a predominantly southwest current and resulting warmer weather is readily evident from the charts of Figs. 5 and 6 that were developed during February and March, 1945. Further verification of these trends can be found in the December, 1946 chart (Fig. 7) for a warm month as compared to those for the cold months of November and December, 1943 (Figs. 8 and 9).

This build-up normally occurs in November reaching its maximum effect in December and early January with the consequent influx of cold air masses, then subsiding to a great extent in February with occasionally a slight build-up again in early March.

Since this is not intended as a purely meteorological discussion, but deals chiefly with local climatological studies, let us examine a one year's investigation on the effect of exposed water surfaces on temperature.

During the 1940-41 season, an interesting experiment was carried on at the Everglades Experiment Station's water table plots, each of which covered approximately ¾ of an acre, with individual water tables in the soil at different levels. Two regular, vegetable type shelters equipped with Weather Bureau standard recording thermographs and minimum thermometers were placed in the middle of each plot, one with a constant three foot water table and the other with one at 1½ feet below the surface of the soil. The two shelters were thus about 100 yards apart, facing the north on an east-west line. During the season, thermographs and minimum thermometers were constantly changed back and forth in order to eliminate any possible instrumental error. The results were found to be as follows.

During nights of large inversion (i.e. ideal frosty nights) the temperature averaged 1.8 degrees higher on the 1½ ft. water table plot. On eleven nights when the temperatures reached 40 or lower, the temperatures averaged 1.4 degrees higher. This suggests that, based on one degree protection for every foot difference in water table, a saturated soil would have averaged three degrees higher or more and readily indicates the great protective value of open bodies of water.

This viewpoint is borne out to some extent by the weather on

March 3 and 4, 1947. A threatened freeze was preceded by unusually heavy rains, which in effect produced a completely saturated soil on the farm lands, and created a shallow lake on the uncultivated lands to the south. Weather stations far to the south near the uncultivated sawgrass lands, recorded 38 degrees or higher. The usually, very warm stations near Lake Okeechobee, on the southwest side, and higher lands to the north (which received only about half the amount of rain and consequently became less saturated) recorded temperatures of 33 to 34 degrees. Thus the temperature differences which usually exists between the lands adjacent to the Lake and some distance from the Lake, were reversed.

Additional evidence along this line was shown during the 1945-46 season, when volunteer beans growing in a field 17 miles south of the Lake were not injured during January and February. On the other hand, several frosts occurred on lands near the rim of the Lake on the southeast side, and temperatures as low as 29 degrees at several stations were recorded. The frost-free aspect which prevailed on the normally much colder lands can only be attributed to the water overlying the adjacent sawgrass lands.

As to how much frost protection is afforded by water over the Glades is a matter which must be further investigated, although the above evidence would indicate that considerable protection might thus be provided. Such investigation would probably entail setting instruments at selected points in cultivated and uncultivated areas in the Glades as well as coastal areas. These stations at least at strategic points would consist of "thermometer stacks" or "inversion-poles" with minimum thermometers installed with standard conditions of protection at varying heights preferably up to 25 or 30 feet.

Another important weather factor which seems to have been established during the last few years is the belt of heavier rains which seem to occur in the area beginning near the Bolles Canal at Okeelanta, and extending northeastward over Vinegar Bend and up to Runyon. From the standpoint of the Drainage District interest alone, it would be worthwhile to find out whether this is a temporary phase or one that may continue for some time.

Of special interest to the Glades, of course, is the recurring problem of hurricane type rains during the months of September and October, both as to the warning aspect as well as the climatological pattern over the areas in which the heaviest rains occur.

It cannot be too strongly emphasized, however, that all proposed climatological studies be integrated with the over-all Glades Water Control program.

AN OUTLINE OF NEEDED LEGISLATION FOR LOCAL AND STATE-WIDE WATER CONSERVATION AND CONTROL

Mr. Ralph Blank*

Following, as I do on this program, so many eminent scientists, engineers, and technological experts who have covered the subject of water conservation needs and problems of south Florida so well, any remarks I might make relative to the actual need of legislation, either local or state-wide, would be somewhat repetitious.

I will confine my remarks, therefore, to a summary of pending legislative efforts and obstacles. In my opinion, the solution of South Florida's water control problem will require the closest possible cooperation of local, state and Federal agencies. By cooperation, I mean in money as well as coordination and correlation of research and engineering efforts. The problem is too large for South Florida alone and the Everglades Drainage District Board. Certainly the richest agricultural area of America deserves Federal support in view of the many reclamation projects over America in which Uncle Sam has invested heavily.

It has been said that the people of Florida will probably await some great tragedy before uniting in a competent state-wide conservation program. Yet here in southeast Florida a great tragedy is taking place under our very eyes. Fires set by man together with natural oxidation are responsible for the all too rapid subsidence of America's richest farm land. The most elementary mathematical calculations reveal the shocking answer that the agricultural life of the Everglades will terminate within a comparatively short span of years unless conservation steps are promptly taken.

The Legislature in Tallahassee should very fully recognize that unless Florida's water resources are developed and utilized in an orderly, beneficial and conservative manner, the future development of the state may be decidedly handicapped. Despite the persistent efforts of some of our "rugged individualists" to prevent any constructive approach to the problem on either a state-wide or even an area basis, our citizenry is gradually coming to recognize the principle that the water resources of Florida are the property of all the people and must be put to their highest and best use in the public interest. It is the duty of the State to provide the leadership essential to the wise and effective use of our water resources. It is already late and every day's side-stepping of the State's responsibility assures more serious ultimate consequences.

Florida's Legislature should provide for the development of sound, state-wide water policies; arrange for the collection and publication of information on the state's water resources; prepare long range, properly coordinated plans based upon a careful evaluation of

* Manager, Palm Beach County Resources Development Board, West Palm Beach, Florida.

the long range needs of Florida. The over-all water control program must be carefully coordinated with, and recognize land use projects; work for improved coordination of State and Federal programs and aim to produce effective cooperation between drainage districts, water conservation areas, municipalities and other political subdivisions for the common welfare.

I have lived in Broward and Palm Beach counties for a quarter of a century. During that period comparatively little progress has been made toward the proper development of the Everglades except by private enterprise in limited sectors and by the Everglades Drainage District under great handicaps. The Everglades today stands as a tragic monument to the exploitation of political and private interests both within and without the district. It has been sacrificed on the altar of stupidity, prejudice, greed and selfish manipulations. Some of these politicians and vested interests still serve as formidable obstacles of Water Control progress, masquerading as apostles of local control and individual rights. Unless our people recognize quickly the tactics and motive of these self-appointed Messiahs who, like Nero, would fiddle as Rome burns, our great Everglades will rapidly become lost to agricultural development.

Let us not be misled by the bugaboo cry of control from Tallahassee. It is our opinion that a competent, workable program can be developed without local agencies surrendering their functions to the dictation of any power, bureau, or commission at our far-distant State capitol.

Last September some of us undertook to develop a Water Resources Bill for submission at the meeting called by the Governor's Committee on Water Conservation at Lakeland November 8th, 1946. At the outset let me emphasize this bill has never been discussed with the Governor; neither was it submitted to the Lakeland Conference November 8th as it was quite apparent that there was not a sufficiently responsible, state-wide representation in attendance, willing to lay aside prejudices, political and economic, or revamp their economic philosophies in order to make a genuine attempt to bring about a meeting of minds upon the subject. Time does not permit the review of this proposed bill here this afternoon. I am, however, attaching a copy hereto for the record with the hope it may appear in the proceedings of this meeting.*

May I add that this bill was prepared with the generous assistance of the U. S. Department of Agriculture. We were fortunate in procuring the loan of the services of an outstanding Federal Authority who is familiar with and has had a part in the drafting of successful legislation for many states involving their water resources problems and particularly with the objective in mind of creating a sound, workable and acceptable agency for the negotiation of Federal assistance. The bill was also designed, in a spirit of compromise, to meet as far as possible, sincere objections to the Water Resources Bill submitted at the 1945 Session of the Legislature. This bill to which reference is made is democratic in spirit, and vests control in a citizens' commission representing all Congressional Districts of the State, serving without remuneration. It recognizes to the fullest pos-

* See Appendix page 168.

sible extent commensurate with "the multiple purpose and coordinated development" of the over-all plan, all existing drainage and water conservation districts as well as municipalities and other political subdivisions.

During the past twenty years literally hundreds of meetings have been held upon the subject of water control in the Southeast Florida water shed. Collectively, we are far more conscious of the seriousness of our water problem than other sections of the state. Untold thousands of dollars and thousands of man hours have been spent in research. Many of the best engineering minds have been employed upon this problem. April 20, 1946 at Belle Glade we presented to the U. S. District Engineer at a formal hearing testimony, research findings and data, which we are advised will still require some ten months for digest and analysis at an estimated cost of $30,000. Our very progressive Everglades Drainage District Board, through its engineers, is constantly adding to our research knowledge. Various Sub-Drainage Districts, the City of Miami, Fort Lauderdale, the Engineering Staff of industrial corporations and the U. S. Soil Conservation Service have made notable contributions. Last, but not least, we are immeasurably indebted to the U. S. Geological Survey for invaluable data indicating the proper approach to our problem.

The people of Florida may not be ready to proceed with a plan of action but self preservation and common sense demand action in our Southeast Florida water shed. Our very economic existence cries for action. The water supplies of our coastal cities are threatened and consequently our tourist economy is in jeopardy. Our agriculture is constantly menaced by either droughts or floods. Just how long our vegetable farmers can withstand their recurring annual losses is problematical. Certainly with marginal profits decreasing in normal times, many of these hardy pioneers of the Everglades will be forced into bankruptcy or submarginal living. We hear much about Ramie as a great agricultural and industrial potential for South Florida but its future is definitely at stake to say nothing of our budding cattle development, sugar cane and diversified agricultural enterprises.

Southeast Florida must proceed with its own legislation which may well serve as a pattern for the rest of Florida. The Everglades Drainage District, I understand, will submit seven bills at the approaching session of the Legislature designed to accelerate proper water control and to make possible more effective cooperation with the Federal Government. I trust that these bills will have the full support of the Soil Science Society of Florida.

In conclusion, may I urge a permanent organization of the people of all Southeast Florida counties interested in Research and Conservation. My good friend, Dr. Allison, originally suggested the name South Florida Research Council. The other day at Fort Lauderdale a Southeast Florida Conservation Council was endorsed to spark a sustained and united drive for action upon our water problems. In our Palm Beach County Resources Development Board a committee of approximately 45 men working consistently together for the past three years have made notable headway in making our county conscious of the desperate need for water control.

May I appeal for united action of all Southeast Florida interests—our coastal municipalities, our sandy loam coastal farmers and dairymen and our Everglades farmers are all "in the same boat"—all dependent upon a common water supply. Lake Okeechobee and the Kissimmee Watershed affect the welfare of every citizen of Miami, Fort Lauderdale, and West Palm Beach as well as every farmer in the Everglades. We still have a great problem of education. Effectively organized at home we can with reasonable assurance of success approach State and Federal agencies to match our efforts for they too have a vital stake in our Everglades economy.

SYMPOSIUM III: PRODUCTION OF LONG VEGETABLE FIBERS IN FLORIDA

Everglades Experiment Station, Belle Glade, April 5, 1947; 10:00 A. M.

OUTLOOK FOR THE PRODUCTION OF LONG VEGETABLE FIBERS IN SOUTH FLORIDA

Dr. Brittain B. Robinson*

I appreciate the honor of being invited to speak at this symposium held at the official opening of the new Plant Fiber Research Laboratory of the Everglades Experiment Station, Belle Glade, Florida. Possibly my long experience (some 23 years), of working with plant fibers other than cotton makes me realize the opportunities that lie ahead of the workers assigned to the laboratory compared with the difficulties their predecessors may have encountered in conducting fiber experiments. For many years Federal and State supported cotton investigations have been conducted throughout our Southern States, but Federal and State work with plant fibers other than cotton has been mainly confined to work in the northern part of the United States on flax and hemp. More than 50 years ago a small temporary laboratory for investigating the production of fiber plants was set up at Cocoanut Grove in the Biscayne Bay area of Florida, and, considering the short period it operated a great amount of experimental data was accumulated. Some of the early history of fiber plants in Florida is recorded in published reports which in part evolved from the work conducted at the Biscayne Bay fiber laboratory.

World and Western Hemisphere Need of Plant Fibers

It is hardly necessary to call to your attention the critical shortages that exist today for nearly all types of cordage and bagging materials made from plant fibers. It frequently has been stated that the position of the United States is as critical today in reference to available supplies of cordage as at any period during the war. Sisal and abaca, the two principal fibers imported for cordage manufacture, are still among the few strategic materials allocated for utilization under the conservation program inaugurated for stragetic materials during the war. There is also a short supply of jute. Due, it seems, to restrictive planting policies of the Bengal Government in an effort to maintain higher prices and to the replacement of jute with food crops to feed the densely populated East there has been created the short supply of bagging material. Undoubtedly the warehouses and shelves of the retailers throughout the world have become relatively bare of all commodities of these fibers during the war period as normal production for civilian utilization was restricted for the production of war needs. Possibly many countries have suffered from short supplies of cordage and bagging more severely than the

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United States as we have been fortunate in our trade relations, in having finances to buy and ships to transport to our advantage.

Possibly to many it may be unknown and even surprising to some that the per capita annual consumption of jute is approximately 1/4 to 1/3 that of cotton, or about 7 lbs. (800,000,000 lbs. total U. S.) This quantity of jute is used in many agricultural and industrial fields where it is practically indispensable. Hard fibers are consumed to the extent of approximately 3.5 per capita or roughly 450,000,000 lbs., total U. S. The figures are for the United States and do not take into account the large quantities of these fibers required by other western hemisphere countries.

Unfortunately most western hemisphere countries are not surplus producers of such fibers. While Mexico, Cuba and Haiti usually have an exportable surplus of henequen and sisal it is far from adequate for western hemisphere needs. The production of jute and jute substitutes has been fostered by the Brazilian government for the past ten years. Though they have gone well beyond experimental production they still do not provide large exportable surpluses.

The production of abaca was inaugurated in Central America as a war measure. The prospective production when the present plantations are well established is under our peace time requirements. However there are uncertainties regarding the permanence of this war enterprise that merit serious consideration in studying our domestic needs.

If these fiber programs and policies can be continued in Latin America, they would seem to be very advantageous. They would give the western hemisphere a source of strategic materials in times of war. They would improve our national position in having sources of supply of these fibers closer to home and shipping would be less difficult than existed in the past two wars. Further, such production would favor our good neighbor policy with our Latin American neighbors and stimulate trade with them in non-competitive products which should be of permanent benefit.

Industrial Plant Fibers of Today

Although 2,000 or more miscellaneous plant species have been listed as producing plant fibers that have been utilized to some extent, there are only about 30 of commercial importance, Table 1. These are:

(1) Bast or stem fibers, jute, flax, hemp, ramie, sunn, chingma, kenaf and **Urena lobata.**

(2) Structural or leaf fibers, abaca, sisal, henequen, mauritius, phormium, Tula istle, palma istle, Jaumave istle, letona, cabuya, fique, caroa, maguey, cantala, pina, palmetto, raffia, palmyra, kittool, crin vegetal, esparto, Spanish moss, and three of four piassavas.

(3) Surface fibers, cotton, kapok and coir.

Possible Adaptation to Florida

All the commercial fibers mentioned above might be grown to some extent in Florida. However, some would grow much better than others and the profitableness and practicability of growing many is seriously doubted. In addition to the commercial industries of cotton, palmetto and Spanish moss which exist at present in Florida many

Table 1—Principal Plant Fibers Utilized by Man and Entering International Trade.

Name of Fiber	Plant Name Botanical	Type of Fiber	Country of Origin	Principal Uses
Jute	Corchorus spp.	Bast	India	Textiles
Flax	Linum usitatissimum	do	Russia etc.	do
Hemp	Cannabis sativa	do	do	do
Ramie	Boehmeria nivea	do	China, etc.	do
Sunn	Crotalaria juncea	do	India	do
China	Abutilon abutilon	do	Manchuria	do
Kenaf	Hibiscus cannabinus	do	India	do
Caesar Weed	Urena lobata	do	Congo, Brazil	do
Sisal	Agave sisalana	Structural	Africa, etc.	Cordage
Abaca	Musa textilis	do	Philippines, etc.	do
Henequen	Agave fourcroydes	do	Mexico, Cuba	do
Phormium	Phormium tenax	do	New Zealand	do
Caroa	Neoglaziovia variegata	do	Brazil	do
Tula istle	Agave lecheguilla	do	Mexico	Brushes
Palma	Samuela carnerosana	do	Mexico	Twines
Jaumave istle	Agave funkiana	do	Mexico	Brushes
Cabuya	Furcraea cabuya	do	Ecuador	Cordage
Cantala	Agave cantala	do	Philippines	do
Mauritius	Furcraea gigantea	do	Mauritius	do
Fique	Furcraea macrophylla	do	Colombia	Sacks
W. Africa Bass	Raphia vinifera	do	West Africa	Brooms
Monkey Bass	Leopoldina piassaba	do	Brazil	Brushes
Esparto	Stipa tenacissima	do	Algeria	Paper, twines
Crin vegetal	Chamaerops humilis	do	do	Filler
Piassaba Bahia	Attelea funifera	do	Brazil	Brushes
Palmyra	Borassus flabellifer	do	India	do
Coir	Cocos nucifera	Surface	do	Filler, brushes
Raffia	Raphia ruffia	do	Madagascar	Twine
Kittool	Caryota urens	Structural	Malasia	Brushes
Palmetto	Sabal palmetto	do	United States	do
Spanish Moss	Tillandsia usneoides	do	do	Filler
Kapok	Ceiba pentandra	Surface	East Indies	do
Cotton	Gossypium spp.	do	United States	Textiles

Table 2—List of Fiber Plants which are Grown Commercially or Have Been Grown or Processed Experimentally in Florida.

Name of Fiber	Plant name Botanical	Commercial or Experimental
Jute	Corchorus capsularis	Experimental
Flax	Linum usitatissimum	do
Ramie	Boehmeria nivea	do
Hemp	Cannabis sativa	do
Sunn	Crotalaria juncea	do
Kenaf	Hibiscus cannabinus	do
Caesar Weed	Urena lobata	Wild & Experimental
Okra	Hibiscus esculentus	Experimental
Sisal	Agave sisalana	Commercial
Henequen	Agave fourcroydes	Experimental
Mauritius	Furcraea gigantea	do
Sansevieria	Sansevieria spp.	Wild & Experimental
Yucca	Yucca spp.	do
Pineapple	Ananas sativa	Experimental
Pine	Pinus spp.	do
Kapok	Ceiba pentandra	do
Coir	Cocos nucifera	do
Spanish moss	Tillandsia usneoides	Commercial
Palmetto	Sabal palmetto	Wild & Commercial
Cotton	Gossypium spp.	Commercial

of the fiber plants listed have been grown in this state experimentally, Table 2, i.e., jute, flax, ramie, sunn, kenaf, **Urena lobata,** sisal, henequen, mauritius, kapok and several palms. In addition to the various fiber plants mentioned other miscellaneous ones have been the subject of investigations in the past in Florida i.e. Sansevieria species, yucca species, **Ananas sativa,** okra and pine leaves. Undoubtedly many others have been experimented with to some extent, but the results are not familiar to the speaker.

There have been in the past several commercial attempts to grow and prepare fibers of sisal and ramie.

Sisal was introduced into Florida by Dr. Henry Perrine in 1836-1837. Fifty tons of fiber were reported produced at Key West about 1870 and shipped to New York. In 1892 the Florida Fiber Company at Jacksonville planned to devote 1,300 acres to sisal and did set out extensive nurseries of young plants. A cordage mill was built at St. James City on Pine Island, Florida, and some sisal planted near the mill. A planting was made near Goulds in 1916 and additional ones in other localities but no permanent production resulted, and such attempts are history.

You are all familiar with the present status of ramie in Florida and the enthusiasm which exists here in reference to its development. For some unknown reason ramie did not attract attention in Florida as early as it did in several other States. However, limited acreages of ramie were planted in Florida before 1900, and several companies have been developed here since that date. It is recorded history that the enthusiasm and beliefs of the people attempting to develop ramie 50 years ago were as great as exist at present.

Various officials of the State of Florida have recognized the potentialities of producing plant fibers in the State. Such recognition is shown by bulletins published in reference to the fiber bearing plants of Florida issued in 1895, 1934, 1938, and two devoted entirely to ramie in 1945.

Growth vs. Commercial Production

Although it has been stated that many different plants may be grown in Florida and many additional ones could be grown other than those tested to date, it is unfortunate that most might not be profitable. To illustrate this, one might point out that cotton will grow in southern Florida, but other areas of the United States are better adapted to its production and cotton is not a major or even a minor industry in southern Florida. Many fiber plants must be strictly classified as tropical plants, and Florida does not have a strictly tropical climate in spite of the literature put out by tourist agencies to attract Northerners to this area in the winter. While many of the tropical plants might grow, their growth is retarded during the cool winters and injuries occur due to occasional light frosts. This makes production of such susceptible plants in Florida unprofitable in competition with tropical countries. Such condition excludes private investment and prevents a fiber development, which would only occur if a nationalistic policy were established favoring the production of our own articles of consumption.

Some soft fiber plants as hemp which have proven superior properties of strength, flex, wear life, etc., to jute have very limited markets in the United States, at prices above jute. Normally hemp

may command twice the price of jute to the extent of possibly 2,000 tons of fiber annually in the U. S. Larger offerings of hemp seem to depress the price and exceed the market demands. As a result of the limited demand and cost of culture, hemp production has been limited in recent prewar years to less than 3,000 acres.

Other things being equal the greater the acre yield of fiber produced by a crop the larger the financial return as compared with fiber crops that yield less. Table 3, gives an approximation of the average yield of some of the common fiber plants in areas of present production. The high yield of many of the fiber plants, i.e. sisal and jute compensate to some extent for the low prices these fibers have commanded in comparison with cotton and flax, Table 4. The second section of Table 3 presents some experimental yields to indicate the possibilities of growing some plants under different conditions of adaptation. Ramie may well illustrate the point. Upon well managed and highly adapted soils in the Everglades, yields of more than 1000 pounds per acre of degummed ramie fiber have been calculated from experiments. Similar high yields might be expected upon some mineral soils but many of our mineral soils are not so productive. Experiments on a mineral soil in southern Alabama yielded only 98 to 464 pounds of fiber. This may serve to illustrate that the yields and financial return may depend upon selection of plant, soil, area of adaptation and any of several other factors.

Table 4 shows the price range for certain fibers in the United States. The value of any new introduced fiber is frequently judged by the value of the fibers with which it will compete in a certain field of finished goods. Unfortunately the big demand is for fibers of low price for low-priced finished goods and hence this means cheap production for an industry in the United States which, considering our high labor costs, is difficult. In reference to practical demon-

Table 3—Production Possibilities of Fiber Plants in Regard to Average Yields of Spinnable Fiber per Acre and Source of Data.

Name of fiber	Yield per Acre (pounds)	Source of Data (country)	Possible Uses
Cotton (1935-1944)	244	United States	Textiles
Flax	400	Oregon	do
Hemp	800	Wisconsin	do
Ramie	400	China	do
Sunn	440	India	Oakum
Abaca	1800	Philippines	Cordage
Sisal	1100	Haiti	do
Phormium	1000	New Zealand	do
Mauritius	1000	Mauritius	do
Jute	1200	India	Textiles
Experimental and Calculated Yields from Small Plots			
Ramie*	1000	Everglades	Textiles
Ramie	98-464	Alabama	do
Kenaf	28-3100	Alabama	do
Urena Iobata	14-2000	Alabama	do
Crotolaria juncea	277-445	Alabama	do

*Est. 20 tons yield, 3-½% fiber less 28% gums.

stration the production of hemp, kenaf, **Urena lobata**, Crotalaria and various Malvaceae and Tiliaceae species in Florida would all be considered as jute substitutes and hence only command jute or even lower prices. Unfortunately the properties of these fibers, as known, are not sufficiently different to justify a spinner paying more for their use in articles normally made of jute.

Table 4.—Relative Value of the Principal Plant Fibers Consumed in the United States.

Name of Fiber	Average Fiber Value (cents per. lb.)	
	1935-39	1940-44
Jute*	4.7	7.1
Cotton**	10.7	18.4
Sisal & Henequen***	4.0	5.2
Flax***	21.7	26.9

* Jute, medium grade, New York
** Cotton middling 15/16 average 10 spot markets
*** Average declared value of all imports

Until we learn more in regard to the value of some miscellaneous fibers for an important, specific use our contemplated potentialities of long fiber production must be considered as cordage or jute substitutes. Ramie may be an exception as a flax and cotton competitor where its high market value offers distinct possibilities of profit in comparison with jute and cordage fibers.

Immediate Future Fiber Market

Mention already has been made of the critical fiber situation which exists today as a result of the shortages which have developed. To some extent there appears from the short range viewpoint little immediate hope of remedying this situation in the next year. Before the war large quantities of hard fibers were obtained from the Netherlands East Indies. These islands have not reorganized their governments and industries so that trade could be re-established. While the sisal plantations may have escaped severe war destruction they are old, and little replanting is known to have taken place during the war years. Sisal plants live about 10-12 years, so the productive period in the Netherlands Indies has likely been made relatively short and any new plantings will require some three years to become productive. Unsettled conditions in the Philippines are holding back and partially destroying the production of abaca on the former Japanese plantations. The need of growing food crops etc. has seriously curtailed the production of abaca and the production in 1947 may be only one third of normal. The plans for planting jute in 1947, while somewhat more extensive than in 1946, are not likely to entirely remedy the bag shortage. These conditions, together with somewhat similar conditions in many other countries, have created an interest on the part of manufacturers in almost any project that promises new sources of raw materials.

Florida Possibilities

If I could at this time foresee that a new fiber plant would create a big industry in Florida, it would be a fitting climax to say

so at this time and point out the reasons in support of my opinion. Though I do not have foresight, facts and opinion that a new fiber holds such immediate promise I do believe that there are decided potentialities of doing something worthwhile here. The high productivity of ramie in the Everglades, its high price at the present time and the interest of various industries to try it out, makes it a profitable crop. It is to be hoped it can be expanded and made to grow bigger and bigger by continuous market demand and profitable prices so that advantage can be taken of its inherent valuable properties. No fiber has had more sorrowful trials or is more deserving of success.

Sansevieria has proved very productive in limited areas of Florida, and much progress has been made in determining, through a war initiated project, methods of propagation, fertilizer requirements, periods between harvests, effects of mulching and irrigation and ways of fiber cleaning to produce a high yield of cordage fiber per acre. For specialty cordage uses there is a small demand for this fiber in the United States supplied at present by imports from Mexico. Should the demand increase and be sustained for a prolonged period at good prices the development of a frost resistant selection of this fiber plant and the development of machines to harvest would lead to commercial planting potentialities in southern Florida.

Table 5.—Fiber Plants Worthy of Experimental Study under Florida Conditions

Name of Plant	Plant Family	Type of Fiber
Lavatera arborea	Malvaceae	Bast
Wissadula rostrata	do	do
Malva spp.	do	do
Urena spp.	do	do
Abutilon spp.	do	do
Sida acuta	do	do
Malachra capitata	do	do
Hibiscus spp.	do	do
Kosteletzkya pentacarpa	do	do
Triumfetta rhomboidea	Tiliaceae	do
Cephalonema polyandrum	do	do
Corchorus spp.	do	do
Sparmannia africana	do	do
Touchardia latifolia	Urticaceae	do
Urtica spp.	do	do
Boehmeria nivea	do	do
Abroma augusta	Stercutiaceae	do
Cannabis sativa	Moraceae	do
Crotalaria spp.	Leguminosae	do
Aechmea magdalena	Bromeliacea	Structural
Neoglaziovia variagata	do	do
Arundinaria spp.	Gramineae	do
Arundo donax	do	do
Sansevieria spp.	Liliaceae	do
Sabal palmetto	Palmae	do

Table 5 lists fiber plants that seem to offer the greatest possibilities of doing well in experiments in Florida. Plant breeding studies with these relatively unimproved plants and investigation of their fiber properties may increase their potentialities. The possibilities of finding fiber crops that will grow well in Florida would not seem to be difficult. The development of industries to utilize such plants will depend upon future work in the laboratory in determining factors of cheap production and finding desirable fiber properties that will enhance their value in comparison with competitive fibers that are available from other sources.

FIELD CULTURE OF RAMIE UNDER EVERGLADES CONDITIONS

Mr. J. M. Dempsey*

During the period 1941 through 1943 Newport Industries, Inc., carried out an extensive research program to determine the commercial possibilities of **Boehmeria nivea** or ramie. These investigations included studies of ramie growth in various areas and under varying conditions of climate and soils. Also included in this program were fertilization studies, determinations of green tonnages, fibre yields and characteristics.

Heretofore in this country while ramie had created considerable interest from time to time it has never been grown commercially. Possibly, due to the fact that it grows rapidly and is a perennial, ramie has been considered a simple and easy crop to grow. In fact, many references in the literature indicate that ramie is a weed. Such assumptions are not true. We have found that ramie is exacting in its soil and climatic requirements. Only under proper conditions will the plant flourish and give optimum yields.

The results of our investigations, which were substantiated by Dr. Neller's studies, indicate that peat soils of the Everglades are ideally adapted for ramie due to their high organic content and physical makeup. Climatic conditions were found suitable; however, proper water control was found to be a most important requirement. It was learned that peat soils in the Everglades area produced high tonnages of green plants and that the fibre was comparable in strength to samples from other countries. Significantly it was found that ramie grown on peat soils contained 40% and more recoverable fibre in the green plant than ramie of the same variety grown on mineral soils which are lower in organic matter. A general air-view of the plantation and a closer one of the plant are shown in Figs. 1 and 2.

In the summer of 1944 Newport Industries, Inc., and the United States Sugar Corporation prepared land and planted 500 acres of ramie. The variety used was U.S.D.A. plant introduction No. 87591, a prolific, high-yielding type selected as the best of 3 types by the Everglades Experiment Station for peat soils. In 1945 an additional 500 acres were planted, followed by a 300-acre planting in 1946. These plantings were made under a number of varied conditions both on previously cultivated and on raw Everglades peat. It is now possible after three years of plantation operation to draw certain conclusions regarding the large scale cultivation of ramie in the Everglades area.

Land Selection and Preparation

Probably the most important phases of establishing a ramie planting are proper land selection and its preparation. Ramie will tolerate little flooding, especially when young, hence the land should be level, free from low spots which might become water logged, and free from burned spots. Whether old or new land is selected utmost consideration should be given to adequate water control facilities not only as protection from periodic heavy rainfall, but for irrigation

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purposes in the dry winter season. Since ramie is a shallow rooted plant it requires maintainance of a fairly high water table.

We have roughly classified the Everglades peat soils into two general types, old or previously cultivated peat and raw or new peat. Our experience indicates that the newer land is preferable since it is more open, drains more readily and is relatively free from weeds and grass which competes with new plantings and make cultivation costly. New land, however, is harder to prepare, drier during the winter months and usually possesses poor capillary action.

Our first plantings were made in 40-acre tracts. Later plantings were in 80-acre blocks. Initial land preparation in either case consisted of clearing, if necessary, plowing, discing, mole draining, pretreatment with copper and a rest period of several months. Just prior to planting the land was disced several times until it was in a good state of tilth, followed by dragging to insure a level surface. Since ramie is a quick growing, shallow rooted plant, it does better in an open, well prepared soil.

Digging

Ramie is usually propagated from root cuttings although it is possible to propagate from seed, butt stem cuttings and by layering. The latter three methods are least preferred, since they require more labor and much more time to establish a stand.

One of the simplest and cheapest methods of digging root stock is by the use of a mold-board plow equipped with a sharp colter. If the root bed is several years old it has usually covered the soil to a depth of 4 inches with a blanket like network of roots. These roots may be plowed out in two-foot strips.

After plowing the root mat is cut into blocks with a cane knife, the roots shaken to remove excess soil and piled. They are then ready for cutting. Roots dug in this manner require less cutting as much of this work is performed by the colter.

Cutting

The root system of ramie is comprised of two distinct types of roots. The stem bearing lateral roots known as rhizomes are used as propagating material. The succulent tap roots, which do not bud, are unsuitable for planting. The number of rhizome cuttings obtainable from one parent plant increases with its age. One year old roots are usable, but contain a large quantity of immature rhizomes. This type of planting material will yield roughly 15.1. Three year old roots have yielded 80.1. Thus it is possible to plant a substantial acreage from a relatively small seed root bed.

The cutting of root stock is a laborious operation. Unless it is carried out on a systematic scale it can be quite expensive. Root cutting should be carried out in the shade, preferably under an open shed, providing protection from the sun. For this operation, the cutting crew should be comprised of men who do the actual cutting on tables, men to keep the cutters supplied with roots, a clean up crew to remove trash and a crew to gather up the roots, and keep them wet down.

The woody, dark brown older roots are much more hardy and viable than the light brown younger roots although the latter are used as secondary planting material but planted double to insure

a stand. The parent or crown root is also good planting material but requires splitting into small pieces with a hatchet or cane knife. Approximately 50% of the uncut roots are discarded during the cutting operation as debris. The rhizomes are cut into pieces ranging from 4 to 8 inches in length with a sharp knife. One man is capable of cutting approximately 4,000 roots per day. After cutting the roots are sacked and are kept wet down until they are planted. Precaution should be taken to see that the roots are kept damp and are planted as soon as possible after cutting. They dry quickly in the sun, losing viability.

Planting

Due to uneven distribution of rainfall in the Everglades, ramie should be planted only when there is adequate soil moisture and preferably during the growing season. Plantings may be made from May through August. Late Fall plantings are not advisable due to the possibility of excessive rainfall and repeated frosts. Early plantings permit the plant to become well rooted before fall.

Due to the open nature of peat soil ramie may be planted in rows 4 feet apart and will shade the middles in sixty days. Good cover is usually attained after twelve months, although the initial rows are more densely rooted and may be noticeable after several years. Our earlier plantings were spaced 2x4 feet, the equivalent of approximately 5,450 cuttings per acre. Later plantings were made 3x4 feet or 3,630 cuttings per acre. Either of these spacings may be used on old weed infested land, but 4x4 foot plantings on new land have done exceptionally well. This latter spacing is the equivalent of 2,725 cuttings per acre. Wider spacing will reduce planting costs considerably and there is less tendency for the field to become root bound. It is estimated that a field may be cropped from 7 to 10 years before replanting is necessary.

It is our practice to plant on perfectly level ground, opening the rows with a specially constructed 4 row opener equipped with fertilizer distributors. This equipment is capable of opening up to 40 acres per day and simultaneously fertilizing in each row with a mixture of potash and smaller amounts of the sulfates of copper, manganese and zinc.

The roots are hand dropped lengthwise in the furrow at regularly spaced intervals. One man is capable of planting from 1½ to to 2 acres per day, depending upon spacing in the rows. A tractor drawn wooden drag, pulled at an angle, over the rows is an efficient method of covering the roots. This leaves the field in a level condition which is preferable for subsequent harvesting. The proper planting depth is 2 to 4 inches. Shallow plantings cannot be covered properly and may fail if the weather is dry. If planted too deep, the roots sometimes die or at best send up spindly stalks.

First buds will appear through the soil after 7 to 10 days. Some old crown roots take as long as 3 weeks to send up buds. After that time skips should be replanted. If poor stands are obtained, say 70% or less, it is cheaper to completely replant the field. Properly planted fields should have a 90% stand or better and skip replanting is unnecessary.

Cultivation and Maintenance

Ramie plantings on new land require little cultivation. Some-

times one spot hoeing will be sufficient. Weedy fields, usually associated with old land, may require as many as two hand hoeings and five or six mechanical cultivations before the middles are shaded. Ramie normally requires no further cultivation after the first year.

Once established the maintenance of a ramie plantation consists of the following principal operations: Pumping in and out during extreme dry and wet seasons to maintain a proper water table; maintenance of field and lateral ditches and control of weed growth around the edges of the field with a weed chopper. Ditch bank weeds, Hyacinths and other aquatic growth may be effectively controlled by spraying periodically with the proper chemicals.

Harvesting

The first crop after planting is somewhat stunted and, since it branches, is considered unfit for harvest. It is mowed anywhere from the 60 to 75th day, depending upon appearance of new buds as indicating a new crop.

Early spring planting will yield one usable crop the same year. Summer plantings are harvested first crop the following year.

The ramie plant is markedly affected by photoperiodism. In the Everglades area fields harvested after August 15th., usually do not produce a satisfactory third crop. During the late summer, ramie matures quickly and seeds. While the plant grows during the winter months, it seldom reaches a height of more than 4 feet due to the short daylight period. Ramie is also highly susceptible to frost. Light frosts will defoliate while heavy frosts will kill the stalk, although this does not damage the roots. Repeated frosts are not desirable since they exhaust the ready buds. In this case, the damaged immature stem will usually branch at ground level yielding a poor crop. The same damage may result from mowing immature plants.

Usually, it is best practice to leave the winter growth untouched until early spring at which time it may be mowed and left in the field. It is possible, with some degree of success, to stage ramie about the time first spring growth begins provided there are ample new buds at the time of mowing. The old winter growth will hold back some of the buds. This permits a longer harvest period.

The first ramie crop is harvested between the 65th and 75th day, depending upon the last frost. This crop is at cutting maturity between April 15th., and May 15th., second crop matures in 60 days and 3rd crop in 55 days. Of the three crops, the second generally yields the greatest green tonnage of fibre, the first crop next and the third least. Each cutting will yield from 8 to 12 tons of green plants per acre. At cutting maturity, the green plant will contain from 3.5 to 4.5 percent of raw fibre containing 20% gums. The percentage of fibre in the green plant increases appreciably during the last 10 days before cutting maturity. It is then stationary for 2 or 3 weeks after which time the plant becomes woody and difficult to decorticate.

At cutting maturity the ramie plant will range in height from 5½ to 7½ feet. The lower sixty percent of the stems are leaf free. A remarkable degree of uniformity in growth is attained with good stands. First year stalks are generally the tallest and largest in diameter. They are also somewhat more woody. Second year stalks and thereafter are more numerous and smaller in diameter. The

time for harvesting may be determined by several indications, such as degree of browning of the stem, releafing and new bud growth.

It is our practice to harvest ramie with a specially developed binder. This machine will cut and tie bundles from 100 to 200 tons of green plants per day. Its operation and the subsequent process of hand loading on a truss-wheel wagon train are shown in Fig. 3 and 4.

Pests

The ramie plant is remarkably free from diseases. It is also attacked by few pests. The leaf roller is the most serious pest which must be controlled. Leaf roller infestations, which may begin about the middle of second crop and continue until fall, can be serious. The roller will defoliate half grown ramie, retarding growth and thereby causing considerable undesirable sub-growth. This pest may be effectively controlled by plane dusting the infested areas with 3 percent DDT.

Fertilization

As previously mentioned ramie is fertilized in the row at planting time. If the fields are not cropped that year, 3 crops may be taken off the following year without fertilizing. It is the practice to fertilize once each year during the winter. Essentially the same fertilizer as that used at the time of planting may be employed. The plant is a heavy feeder, especially on nitrogen and calcium. A typical analysis of ramie leaves and stems is given in the table below.

Portion of Plant	Composition (Percent, Air Dry Basis) N	P	K	Ca	Mg
Leaves	3.99	0.19	1.43	6.32	1.17
Stems	1.26	0.31	1.02	0.93	0.40

Ramie growth on burned peat spots will manifest severe chlorosis and stunting due to manganese deficiency. The same holds true if the soil pH is 6.0 or higher or in dry periods when manganese is not available to the plant.

Varieties

Since ramie does not breed true from seed, there are a number of forms and races of Boehmeria nivea. In order to study some of the types, there have been brought in from other countries, some 22 types. Preliminary observations indicate that some of these importations have excellent growth characteristics while others do not. It is proposed to evaluate each variety in the future and bring in others from time to time wherever they can be located for this purpose.

Conclusion

During the past on many occasions we have received valuable assistance and cooperation from Dr. R. V. Allison and the staff of the Everglades Experiment Station and Mr. Mills Byrom and other employees of the U.S.D.A. We are extremely gratified that the State and Federal Government have provided funds for the new fibre laboratory. While Ramie is now passing from the experimental to the commercial stage, there remains much to be learned. Various studies of agronomy will be most helpful including water requirements, planting and cultivation, pest control, variety selection and

breeding. There also exists the need for mechanical research which includes harvesting, decortication and fibre studies. We have faith in the commercial possibilities of ramie and fully believe that it offers a new crop for the Florida Everglades.

Figure 1. General view of ramie plantation near Canal Point with processing plant at left center of the picture.

Figure 2. Close-up of ramie decorticating plant at Newport Industries, Inc., showing racks for air-drying decorticated fiber which it has been necessary to use in the early stages of the development. Fields in background and to right show various stages of harvesting.

Figure 3. Harvesting ramie with a modified hemp binder under Everglades conditions.

Figure 4. Loading binder harvested ramie by hand prior to the mechanization of this phase of the operation.

THE MECHANICAL DECORTICATION OF LONG VEGETABLE FIBERS

Mr. M. H. Byrom*

INTRODUCTION

The need for fibers of various kinds in modern civilization is second only to the need for food. When an adequate supply of either is curtailed, the economy of nations as well as individuals is disrupted.

World War II focused attention on the need of increasing the production of all fibers, especially long fibers, as well as of improving machinery and methods for preparing them for the consumer.

It is the purpose of this paper to trace briefly the development of some of the more effective decorticating processes for long fibers and to point out some of the more efficient mechanical methods for their preparation.

LONG VEGETABLE FIBER

Classification:

Two classifications commonly accepted for long vegetable fibers are bast and leaf. Fibers growing around a woody stem such as ramie, flax, kenaf, jute, etc., are examples of bast fibers. Those growing through a leaf to impart stiffness or rigidity such as sisal, abaca, sansevieria, etc., are called leaf fibers. Each class presents different problems for decorticating. As a general rule, bast fibers require retting before decortication, that is the waxes and gums which bind the fiber to the woody part of the stem are dissolved or consumed by bacterial or chemical action by submerging the stems in water for several days. The stems, after being dried, are then flailed by beaters which break up and remove the woody parts, and free the fiber. Leaf fibers, however, require only that the fleshy or pulpy parts of the leaf be stripped from the leaf to give a free fiber.

Recently it has been found that some of the bast fibers do not necessarily require water retting but the woody parts of the stem can be stripped from the fibers as is done with the leaf fibers. In such cases, it is necessary to remove the gums from the fibers after decortication by chemical or other means.

DEVELOPMENT OF DECORTICATING MACHINERY

Early Developments:

The principal problem since the time of the Pharaohs has been the extraction of the fibers. Crude hand methods are still used in many parts of the world, but quantity production and the necessity of low cost processing requires the use of machines. A brief search through the files of the United States Patent Office shows that one of the first patents on decorticating machinery was granted on Dec. 5, 1854. For a number of years one patent each three or four years was issued. The rate increased until in recent years, 6 to 8 have been granted annually. The total number issued is perhaps well over 500. These cover almost every conceivable mechanical means for treating fiber.

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In outlining a test procedure for the United States Department of Agriculture Laboratory at Boynton, several non-conventional type knives, brushes, etc., were scheduled for test. Most of these were thought to be original at the time. However, a later search through the patent office records revealed that every single one was patented before 1900.

Scutching drums of various kinds employing knives and concaves were in use as early as 1862, but it remained for the Prietos, Mexican engineers and planters, to supply the basic designs on which our most successful present day decorticators are based.

The first United States patent, No. 278,688, was issued to Demetrio Prieto on May 29, 1883, and No. 446,791 on Feb. 17, 1891. Manuel Prieto further improved these machines in 1903 and 1904. Machine No. 138 of series A of these improved machines is still in operation at Opichan, Yucatan, Mexico. Manuel Prieto's patents were No. 703,701 issued June 9, 1903, No. 752,258 issued Feb. 16, 1904 and No. 753,736 issued March 1, 1904.

Later Developments:

Perhaps the most popular machine resulting from these patents was the "Vencedoro". In this machine decortication is accomplished by three rotors operating against concaves. Material fed into a forward pair of gripping chains is engaged near the center. Both the butt and tip end are decorticated simultaneously by separate rotors one on each side of the gripping chains.

The cleaned fiber at the butt end of the leaf or stalk is then caught in a similar off-set gripping device and the center of the material is cleaned by the third rotor. Other popular modifications of this machine use only two rotors set on opposite sides of a pair of gripping devices.

The gripping devices are off-set in such a way that the cleaned fiber from the first rotor, usually a short section of the butt, is caught by the second set of gripping chains which carry the long tip section through the second rotor. Some of these machines, notably the Krupp, make the rotor used to decorticate the short end of the leaf somewhat smaller than the one decorticating the long section. It should be borne in mind that the above machines were designed primarily for decorticating sisal and henequen leaves. Modifications of these machines have been adapted to abaca, ramie, and perhaps other fibers.

EXPERIMENTS AT THE BOYTON LABORATORY

In 1943, the U. S. Department of Agriculture began investigations to determine the economic possibilities of producing sansevieria fiber on a commercial scale in South Florida. To conduct these investigations on the scale planned, a laboratory was set up near Boynton, Florida.

Plan of Operation:

Due to scarcity and high cost of labor, it was obvious that all phases of production, including planting, harvesting, and decortication, should be as completely mechanized as possible. To accomplish this, the feeding of the material into the decorticating mechanism on existing machines would have to be more highly mechanized and made as automatic as possible. The discharge of the fiber would also

have to be made automatic, the fiber going directly from the decorticator into an artificial drier without being touched by hands. If these two operations in the decorticating process could be completely mechanized and made automatic the capacity of the machine would be greatly increased, decortication of the fiber would be more uniform, and the cost of labor would be greatly reduced. Because of its large capacity and dependability it was decided to examine thoroughly the raspador principle of decortication and if possible, to adapt this type of a machine to the decortication of the sansevieria fiber.

After much difficulty an all steel machine having two decorticating wheels 60" in diameter and having a face of 16" was secured. A variable speed drive with an individual motor was provided for each of the scutching wheels and also for the feed mechanism which was of the rotary drum type. Although designed primarily for decorticating sansevieria, this machine also functions satisfactorily with freshly cut ramie and kenaf, which are bast fibers.

Basic features of decortication that are being investigated are:

1. Type of knife or scraper used, which would include shape, sharpness, etc. The number of knives and the spacing on the drum was also to be considered.
2. Speed of the decorticating drum vs. clearance between the knives and the concave. Included in this would be the number of impulses per second on the material, as well as the velocity of the impulse.
3. The speed of the conveyer carrying the material through the decorticating wheel.
4. The effect of water and air currents on decortication.
5. The effect of fiber maturity on decortication.
6. The lapse of time between harvest and decortication.
7. Crushing, steaming, and other treatments to the leaves prior to decortication.

The need for other fibers as well as the limited quantity of sansevieria leaves available for testing caused ramie and kenaf fibers to be included in the investigations soon after work was started.

Type of Knife or Scraper:

The conventional knife used on the raspador machines in Mexico and Cuba worked very well on henequen and sisal leaves, but it appeared to be much too harsh on the tender sansevieria leaves. In order to find a decorticating device suitable for sansevieria, several different types of knives were scheduled for test. A knife was designed that would first, allow easy entrance into the decorticating chamber; second, crush and reduce gradually the plant material; and third, provide thorough cleaning of the decorticated fiber.

Various types of serrated knives and brushes in combination with the smooth knife had to be tested in order to find the most effective method of decortication. It was thought that the method of mounting the knives on the drum, the number of knives, the spacing, etc., might be important factors. These tests are still under way.

Speed of the Decorticating Drum vs.
Clearance Between Knife and Concave:

There appears to be a very definite though not critical relation between the speed of the decorticating wheel and the clearance between the knives and the concave. The optimum speed and clearance

varies with the kind of fiber and the rate at which it is fed into the machine. Generally speaking for any given fiber, as the clearance increases the speed of the drum must also be increased. For example it was found that a wheel of 400 R.P.M. and a clearance of 0.18" gave clean decortication on sansevieria leaves fed at the rate of 6 tons per hour. A speed of 350 R.P.M. and .045" clearance gave good results on ramie fed at the same rate, while a speed of 550 R.P.M. and .025" clearance was required in order to get good decortication on kenaf. It has also been found that equivalent decortication with less fiber loss can be had by operating the wheel scutching the butt end of the material at 50 to 100 R.P.M. slower than the wheel scutching the top end, clearance and feed remaining the same.

Speed of Conveyor:

Relatively slow speed for the feed mechanism gave slightly higher fiber recovery than the faster speeds. The average difference between 30 and 60 feet per minute was just over one percent. In order to secure the maximum out-put it is desirable to operate the feed mechanism at the fastest possible speed consistent with low fiber loss. Ninety feet per minute is recommended.

The Effect of Water on Decortication:

The idea that water aids the decorticating process has long been suggested. From the standpoint of quality it is desirable to wash and clean the fiber as thoroughly as possible. This is especially true for the hard fibers as the plant juices crystallize on drying. These tiny crystals are apt to cut the fiber in the spinning process, and thus lower the quality of the finished product. Tests on sansevieria, ramie and kenaf all show that the percentage of fiber recovered is slightly less with water than when the material is decorticated dry. The difference in the weight can probably be accounted for as pulp and refuse remaining in the unwashed fiber, the weight of clean fiber being the same by either method.

Air Currents:

The knives on the rotating drums act as fan blades and set up air currents that are hard to control. These cause damage and loss of fiber in two ways. First the air currents whip the fiber away from the concave and the approaching knives beat it down again, breaking and combing out fiber. A second source of damage is the tangling caused by uncontrolled air current blowing the fiber out of the decorticating chamber.

The shape of the decorticating wheel, the shape of the knives and the correct application of water and air pressure are all being used to minimize this trouble.

Effect of Maturity on Decortication:

Generally speaking, mature fiber decorticates cleaner and with less loss than immature fiber. This may be due in part to the larger diameter of the individual fibers and also to the tendency of the pulp, bark, and other plant material to cling less tenaciously to the mature fiber. Ramie affords an excellent example of maturity vs. immaturity. Material decorticated when 50 days old gave a fiber yield of 3.25%. 25 days later or when the material was 75 days old, a fiber yield of 4.50% was obtained under identical decorticating conditions. About the same variation between mature and immature fiber has been found to exist in sansevieria and kenaf.

Lapse of Time Between Harvest and Decortication:

Under good storage conditions, sansevieria leaves have decorticated well two weeks or more after harvest. Ramie will not keep that long, but has been successfully decorticated several days after harvest when stored in a cool shade. The amount of space needed to store any great quantity of material awaiting decortication is so great that it would be impractical in commercial production. All fiber plants, including the fleshy leaves of sansevieria and sisal dry rapidly in the sun and should be decorticated in 24 hours after harvest if possible. After that spoilage begins if the material is left in the open.

Treatment Prior to Decortication:

Preliminary treatments such as crushing, steam or other heat treatment, partial retting, and many others have been tried in connection with decortication. Experience with all of these except partial retting of kenaf has been disappointing. It has been found to take from two to three weeks to completely ret kenaf fiber. The retted fiber when thoroughly washed has excellent strength, contains no plant juice or bark, and has a beautiful luster or sheen. Fiber of identical quality and appearance has been obtained by retting for three days and then decorticating on the raspador machine. Tests involving steam treatment have been very limited. Thus far only sansevieria and kenaf have been tried and these have shown very little promise.

MACHINES DEVELOPED FOR FLORIDA CONDITIONS

Any discussion on the decortication of long vegetable fibers in Florida would be far from complete if private research and commercial development were not given a full share of the spotlight. With the hope that you will have the opportunity of seeing many of the machines, talking with the engineers who designed them, and with the men who will operate them, I shall take the liberty of mentioning these developments only in a brief way.

Portable Machines:

The names of Landone, St. John, Short, Gardner, and many others are familiar to anyone who has followed ramie development in Florida. Machines built as a result of the efforts of these men were small, light in weight, low in power requirement and also low in fiber out-put. All have some merit, but none have been widely accepted.

A small machine built by the Japanese and modified by Newport Industries turns out a thin uniform ramie ribbon of high quality. A larger machine of the same type, developed by Newport gave equally good results, but even the larger machine has a low fiber out-put. The decorticating principle consisted of a rotor operating against a short concave or a bar. In operation, two or three stalks were grasped by the butt end and fed into the rotor as far as possible with safety to the hands. These were then withdrawn, reversed, and the remainder of the stalk fed into the machine.

The Siland machine, being developed by Sea Island Mills, Inc., accomplishes similar results giving a beautiful, thin ribbon. This machine has a very ingenious mechanical feed which should give greater capacity with less hand labor. A more uniform ribbon might also be expected.

CENTRAL STATION TYPE MACHINES

There are at least three different machines of the Central Station type that are or soon will be in use in Florida.

Modified Krupp Corona:

A modification of the Krupp Corona machine has been selected and further improved by Newport Industries for their Central Decorticating Plant. The conventional rope gripping devices have been retained, but major changes have been made in the design of the decorticating wheels. Both wheels have been made the same diameter and have the same width face. The face has been curved to allow the use of a knife of uniform width. This design gives a wide throat at the entrance to the decorticating chamber, reduces air currents and prevents excessive harshness of the knife on the fiber. The result is a uniform, clean ribbon with very little tangling. The fiber out-put should be very high for this type machine.

Modified Hemp Scutcher:

A hemp scutcher of the type used by the War Hemp Corporation has been redesigned by the Florida Ramie Products Co. for the decortication of ramie. A fair capacity of clean fiber has been secured from this machine. Company engineers expect to improve the gripping chains and otherwise rebuild and strengthen the machine before putting it into steady operation.

The Reeves Decorticator:

This machine uses the raspador principle of decortication but is unique in that the cutters of the decorticating wheels are on the same line or axis. They are mounted on individual shafts and rotate in opposite directions. The concaves are places on opposite top quadrants of the wheel instead of on the conventional lower quadrant. The machine is very compact and sturdy. The material to be worked on is caught between two corded belts. Gripping pressure is supplied by a series of traveling coil springs mounted on a roller chain. As built by the Goslin-Birmingham Company, the machine is of all steel construction.

Summary:

All fibers are highly competitive for while some have characteristics which make them particularly suitable for certain uses, if scarcity or high prices affect one fiber, another can be used in its place. At present most American fibers compete with similar foreign grown products, so that our costs of production must be kept low to meet world prices. This means that American fiber production must be entirely mechanized for it is obviously impossible for us to use hand labor because of its high cost. All of the operations must be mechanized, planting, harvesting, processing, and drying must be accomplished by machine rather than by hand labor. Research by both public and private agencies has already made some progress toward this objective, but in hardly more than on an experimental basis. These special fibers represent an industry in its infancy and much work yet remains to be done before any of their promises may be regarded as fulfilled. With the continuation of the research work it is hoped that it will not be too long before their possibilities can be determined.

METHODS OF DEGUMMING AND SUBSEQUENT HANDLING OF RAMIE FOR USE IN THE TEXTILE INDUSTRY

Mr. Harry Neiman*

Mr. Neiman's talk was entirely "off the cuff" and under circumstances that made a transcript either mechanically or by means of long hand practically impossible. Since no manuscript to cover was subsequently provided, only the highlights of his discussion will be reviewed. These have been arranged briefly as something of milestones along the way at which points he:

(1) **Verified** Dr. B. B. Robinson's statement earlier in the program of the long-time public knowledge of the essential value of ramie fiber and of widespread interest in its production;

(2) **Regarded** present effort as having a much better chance of success than ever before, especially because of the uniqueness of certain of the qualities to be found in this fiber and the rapidly growing appreciation for its outstanding usefulness in blends with other fibers;

(3) **Discussed** the extreme heterogeneity of the "China grass" of commerce, gathered as it is from a very great variety of small plantings and passing through varying periods of indifferent storage varying from a few weeks to months or even longer before it arrives at port for shipment, and referred to the quality of the material from this source as almost impossible to visualize, requiring 34-36 hours to degum;

(4) **Noted** that while China grass was first available at 62 cents per pound and later at 32 cents, and material of a generally similar quality could be had from Dutch Guiana at 24 cents per pound, he would rather have, in his own operation, Florida-grown and processed fiber at 35 cents per pound than any of the Far Eastern material at 24 cents per pound;

(5) **Surmised** that it is this astonishing quality he has found in the Florida source that gives particular assurance for the success of the project that is now getting under way;

(6) **Stated** that on the basis of his personal experience with both resources of ramie, China and Florida, there is absolutely no comparison between the two and likening the ease of degumming and handling the Florida source, by comparision with the China grass of commerce, "as easy as opening a can of Campbell's soup, diluting according to directions and serving!";

(7) **Outlined** recent improvements in his New York plant involving an investment of thousands of dollars whereby the degumming capacity is to be doubled and the procedure reduced from 8 to 6 hours (itself indicating the less drastic treatment needed to remove the gums from the freshly decorticated Florida ribbons);

(8) **Told** of the splendid experience he had recently had in the weaving of thousands of yards of fine fabrics and how only during the

* President, Sea Island Mills, Inc., New York, New York. (As reported by the Editor.)

past two months had he been able to make fabrics containing 100 percent ramie, the former yardage being used in the manufacture of a large number of sport coats which during the first morning they were offered at widely separated stores sold out completely in the first few hours, the principal comment being "when can we get more?";

(9) **Reviewed** his visits to numerous textile mills in the course of his present trip to Florida and found many operators who were not interested in ramie six months ago now anxious to use the fiber, noting at the same time that one hosiery firm, alone, stood ready to buy 350,000 pounds of ramie yarn in a single order for use in toes and heels, this whole sequence of inquiries causing him to estimate that "If only 2 percent of the demand indicated by tentative request for ramie yarns and fabrics for industrial use materialize, there can't be enough ramie grown in Florida to satisfy the demand;" and

(10) **Called** for a campaign of public education which would bring forth the true value of the fiber and prove that it is fully capable of standing on its own quality; also as a protection against those individuals who are always found following along in a situation of this kind with a propensity to overdevelop or misrepresent the situation for personal gain—and ramie has been quite richly endowed with experiences of this nature.

Mr. Neiman concluded his discussion by permitting the Secretary of the Society to read a remarkably fine statement prepared by him in advance of the meeting which, because of its very great interest in the future of the ramie industry and its obvious sincerity, we have come to regard, with no facetiousness whatsoever intended, as:

A SILAND PRAYER

WHILE THE ROMANTIC HISTORY OF THE DEVELOPMENT AND USE OF RAMIE LENDS ITSELF ADMIRABLY TO MODERN MERCHANDISING METHODS THE FUTURE OF RAMIE LARGELY RESTS IN THE HANDS OF THIS SMALL GROUP OF GROWERS AND PROCESSORS.

NO MATTER FROM WHAT ANGLE OUR INTEREST IN RAMIE DERIVES, WHETHER WE BE GROWERS, DECORTICATORS, PROCESSORS OR RETAILERS, THE FUTURE SUCCESSFUL ACCEPTANCE OF RAMIE AS A COMMERCIAL FIBRE DEPENDS ON OUR ABILITY TO FACE CERTAIN FACTS AND IN TURN TO PRESENT THESE FACTS TO THE END USER OF RAMIE, UNDERSTANDABLY AND TRUTHFULLY.

THE END USE OF THE RAMIE FIBRE IS THE CONTROLLING ECONOMIC FACTOR FOR GROWERS AND PROCESSORS ALIKE.

AS WITH A NEW BABY IN THE FAMILY WE, WHO ARE OFFICIATING OVER THE INTRODUCTION OF RAMIE TO THE AMERICAN AND THE WORLD MARKET, ARE SOMETIMES PRONE TO DEAL IN SUPERLATIVES. NEWS ITEMS AND MAGAZINE ARTICLES TREATING OF THIS NEW FIBRE APPEARING IN PERIODICALS OVER THE PAST FEW YEARS HAVE OFTEN PUT FORTH GLOWING CLAIMS AS TO THE PRODUCTIVITY OF THE PLANT AND ITS CASH INCOME TO THE GROWER. SIMILAR ARTICLES HAVE CARRIED STATEMENTS INDICATING RAMIE TO BE TWELVE TIMES AS STRONG AS COTTON, EIGHT TIMES AS STRONG AS LINEN. STILL OTHER WRITINGS HAVE PAINTED A PICTURE OF FINANCIAL RUIN TO COTTON GROWERS, BANKING INSTITUTIONS AND LIFE INSURANCE COMPANIES, ONCE RAMIE HAS BEEN BROUGHT INTO ITS OWN.

IN THE FIRST INSTANCE IT IS A KNOWN FACT THAT THE PRODUCTION OF RAMIE IS A PROFITABLE VENTURE FOR THE GROWER SO SITUATED THAT HE CAN APPROACH THE IDEAL CONDITIONS UNDER WHICH RAMIE IS BEST PRODUCED IN THE FIELD AND FURTHER, THAT HE HAS PROPER FACILITIES FOR HARVESTING AND DECORTICATING ONCE IT HAS MATURED AND, THIRDLY, PROVIDED HE HAS A READY MARKET FOR THE RIBBONS AND BY-PRODUCTS PRODUCED. FANTASTIC CLAIMS ARE OFTEN MISLEADING AND THE FUTURE OF RAMIE DEPENDS FIRST UPON THE ABILITY OF THOSE INTERESTED

IN ITS PRODUCTION AND ITS END USE TO PRESENT THE ACTUAL FACTS TO PROSPECTIVE GROWERS AND TO MAKE AVAILABLE TO THESE GROWERS EVERY BIT OF TECHNICAL INFORMATION POSSIBLE, THEREBY OFFERING THEM SOME CHANCE OF SUCCESS AND ENSURING THEIR CONTINUING INTEREST IN THE PRESENT AND FUTURE OF RAMIE PRODUCTION.

SECONDLY, ILL-CONSIDERED OR UNQUALIFIED STATEMENTS REGARDING INHERENT QUALITIES OF RAMIE FIBRES CAN GO FAR TOWARDS DESTROYING ANY FUTURE MARKET THAT OTHERWISE MIGHT BE DEVELOPED FOR THIS PRODUCT. IT IS QUITE TRUE THAT UNDER CERTAIN IDEAL CONDITIONS, SUCH AS CONTROLLED LABORATORY TRIAL RUNS, RAMIE FIBRES CAN BE OBTAINED, SPUN AND WOVEN THAT WILL MEET THE SEEMINGLY FANTASTIC CLAIMS FOR TENSILE STRENGTH AND ABRASIVE RESISTANT QUALITIES SOMETIMES PUT FORWARD AS BLANKET CLAIMS FOR RAMIE FIBRES GENERALLY.

UNDER PRESENT LIMITATIONS IN THE MILLS, MECHANICAL APPARATUS IS NOT YET AVAILABLE TO CARE FOR THE LONGER RAMIE FIBRES AND IT IS OF PRIMARY KNOWLEDGE THAT THE LENGTH OF FIBRES USED IN THE MANUFACTURE OF ANY MATERIAL LARGELY CONTROLS MANY OF ITS MOST DESIRABLE QUALITIES. FOR INSTANCE, MATERIAL MADE FROM 1¼" COTTON STAPLE IS FAR SUPERIOR TO THAT MADE FROM 7-8" COTTON FIBRES. THE ECONOMIC BASE OF THE COTTON MARKET ITSELF IS WISELY CONTROLLED BY A GRADUATION SYSTEM WHICH DEALS IN FIBRE LENGTHS. WE WHO ARE SERVING AS GODFATHERS FOR RAMIE ARE FACED WITH A UNILATERAL MARKET STRUCTURE IN WHICH THERE ARE NO GRADUATIONS TO DISTINGUISH ONE RAMIE FIBRE FROM ANOTHER AND UNTIL WE HAVE ESTABLISHED RAMIE AND ITS ACCEPTANCE COMMERCIALLY AND ON AN EQUITABLE, ECONOMIC BASIS SIMILAR TO THAT OF COTTON, IT EVOLVES UPON US TO BEAR FOREMOST IN OUR MINDS, OUR PRIME OBLIGATION TO OURSELVES AND TO THE INDUSTRY, THE FACT THAT OUR CLAIMS FOR RAMIE MUST BE BASED ON THE ENTIRE RAMIE PRODUCTION PICTURE AND NOT ON ANY ISOLATED EXPERIMENTAL PRODUCTION OR LABORATORY TRIALS. ONLY THROUGH THE EXERCISE OF EXTREME CAUTION AND OUR ABILITY TO CONTROL ANY EMOTIONAL SALES APPROACH CAN WE HOPE TO BUILD TOWARDS AN ECONOMICALLY SOUND FUTURE IN OUR CHOSEN FIELD.

THIRDLY, FEAR ADVERTISING OF ANY PRODUCT HAS PROVEN DISASTROUS IN THE LONG RUN AND SUCH MAY WELL BE THE CASE IF CONTINUED IN THE ATTEMPTED PROMOTION OF RAMIE. OUR FIRST AND ONLY INTEREST SHOULD BE THE PROMOTION OF THE ACCEPTANCE BY THE PUBLIC OF RAMIE AS AN INDIVIDUAL FIBRE, NOT NECESSARILY ON A COMPARATIVE BASIS WITH OTHER FIBRES BUT STRICTLY ON ITS OWN MERITS, WITH WHICH WE ARE ALL FAMILIAR. IT IS NOT THE DESIRE OF THIS GROUP, NOR IS IT NECESSARY, TO PROMOTE RAMIE AT THE EXPENSE OF ANY OTHER ESTABLISHED FIBRE. RATHER, IT BECOMES OUR TASK TO CONTINUE AND EXTEND OUR PRESENT EXPERIMENTAL WORK AND TO CREATE A NEW MARKET, A RAMIE MARKET IF YOU PLEASE, INDEPENDENT OF AND DIVORCED FROM ANY COMPETITIVE SALES APPROACHES. THE FIBRE ITSELF MAKES POSSIBLE A SUCCESSFUL APPLICATION OF THESE TACTICS AND IF WE, WHO NOW CONSTITUTE IN THIS SMALL GROUP, THE RAMIE INDUSTRY OF AMERICA, WILL BE SO GUIDED AS TO ACCEPT OUR RESPONSIBILITY SERIOUSLY, WE CAN THROUGH EDUCATION AND MODERATION ENSURE A BRIGHT FUTURE FOR OUR INDUSTRY. IT BECOMES A PART OF OUR DUTY TO OURSELVES AND TO THE EVENTUAL END USER OF RAMIE TO SEE THAT ALL INFORMATION REGARDING RAMIE BE FACTUAL, ACCURATE AND UNTAINTED WITH EXCESSIVE CLAIMS OF ANY NATURE WHATSOEVER. ONCE WE HAVE RECOGNIZED AND ACCEPTED OUR RESPONSIBILITIES, WE SHALL HAVE ACCOMPLISHED MUCH IN THE RIGHT DIRECTION.

CERTAIN VARIATIONS IN NATURAL CELLULOSE FIBERS

Dr. Earl E. Berkley*

Natural cellulose fibers constitute 70 to 80 percent of all fibers other than pulps and papers used by man. Although they are all obtained from the plants that grow about us they have widely different origins and varied functions in the organisms from which they are derived. They may be classified according to use by man such as: (a) textile fibers; (b) cordage fibers; (c) upholstery fibers; (d) packing fibers, etc. Since certain of them may be used for more than one type of product, or even in all of the groups listed, a more logical grouping may be according to origin. The more commonly known fibers may be classified as follows:

Origin	Examples
1. Seed hairs,	cotton and milkweed floss;
2. Pod fibers,	kapok;
3. Hull or fruit fibers,	coir;
4. Leaf (hard) fibers,	abaca and sisal;
5. Bast (soft) fibers,	flax and jute;
6. Stem fibers,	Spanish moss;
7. Root fibers,	broomroot.

Within each of these groups there are wide differences in the size, shape and physical properties of the fibers. They may be compared also as to fiber length, cell structure, and whether or not they are: (a) single cell fibers such as cotton, kapok and ramie, when fully degummed; or (b) multicellular strands of fibers such as abaca or jute and Spanish moss.

Certain of the bast fibers such as ramie, flax and American hemp can be used either in strands of many cells or separated into single cells.

Each general type of fiber has certain characteristics that distinguish it from other types. However, within a given group, wide differences in physical properties are not uncommon. These differences may be due: (a) to the species or variety of plant; (b) to the growth conditions; (c) to the cell wall constituents, and; (d) to their physical make-up or fine structure.

In single cell fibers, for example cotton, the physical properties are dependent on the size and shape and the chemical and physical structure of the cell wall, whereas, in multicellular fibers, such as abaca (Manila hemp), the binding layer, designated "intercellular material", between the cells is a vital element in the system.

The cotton fiber, although a single cell, is not simple. The cell wall is composed of (1) primary wall, (2) outer layer of the secondary thickening, (3) central layers of the secondary thickening, (4) when fully mature the inner layer of the secondary wall, and (5) the lumen with the residue of the protoplasm.

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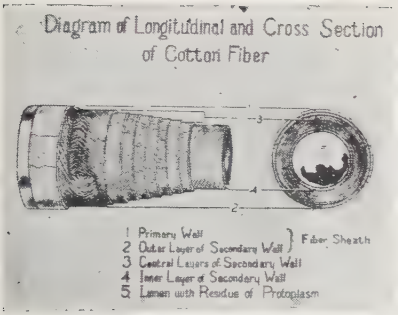
Diagram of Longitudinal and Cross Section of Cotton Fiber
1 Primary Wall
2 Outer Layer of Secondary Wall
Fiber Sheath
3 Central Layers of Secondary Wall
4 Inner Layer of Secondary Wall
5 Lumen with Residue of Protoplasm

Figure 1 (Above) Diagram of cross section and telescoped longitudinal section of cotton fiber, (1) primary wall, (2) first layer, (3) central layers, (4) inner layer of the secondary thickening, and (5) the lumen with the residue of the protoplasm.

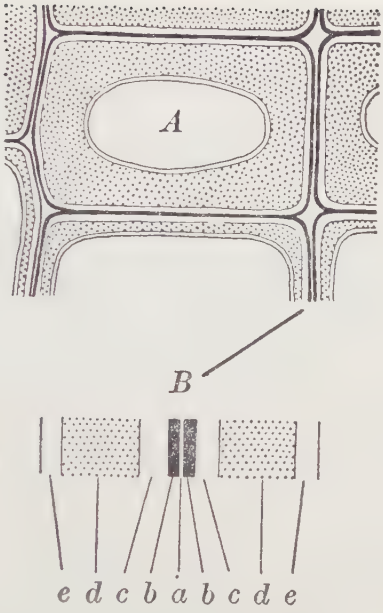

Figure 2.—(Right) Diagram of cross section of (A) one entire cell and parts of others; (B) sections of adjacent walls more highly magnified. a. intercellular material, b. primary wall, c. outer layer of secondary wall, d. central layer of secondary wall, and e inner layer of secondary wall. (Courtesy Kerr and Bailey.)

The primary wall of the cotton fiber contains, in addition to cellulose, waxes and pectic materials and no doubt other compounds. The relatively high shrinkage of this layer of the cell wall, with changes in moisture content, indicates that a large percentage of the cell wall substance is non-crystalline material. Extraction of the waxes and pectic materials increases the tendency to shrink upon drying but does not destroy the continuity of the cell wall.

The multicellular fibers contain all the parts listed for cotton and in addition an intercellular material that binds the cells together. Since most leaf and bast fibers contain lignin the intercellular layer is frequently highly lignified.

The physical properties and therefore the use value of these fibers varies with the structure of the cell walls and in the case of multicellular fibers the binding layer between them. Variations in the orientation of the crystalline cellulose in the central layers of the secondary thickening can be measured with x-ray diffraction technique. In general the cellulose in natural fibers consists of long chains made up of glucose anhydrides linked through the 1 and 4 carbons. These long thread-like molecules crystallize to form the so-called crystallites, long needle-shaped filaments which in turn are bound together in bundles to form the fibrils which may extend the full length of a cell. Within a given fibril the long axes of the cellulose molecules (that make up the crystalline phase), those of the crystallites and that of the fibril of which they are a part lie parallel with each other. The molecules are apparently held together in the crystal by so-called "hydrogen bonds." The crystallites in turn

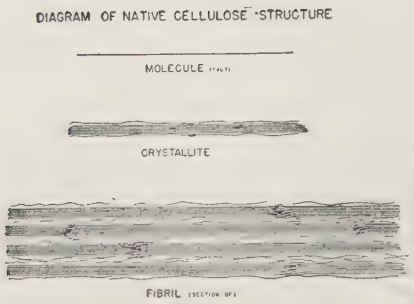

Figure 3.—Diagram representing cellulose molecules, crystallite in native cellulose and a section of a fibril.

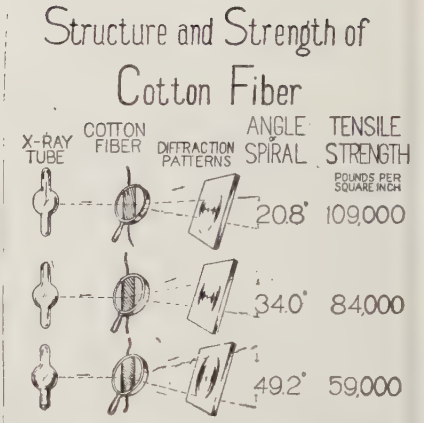

Figure 4.—Diagram showing variations in spiral structure of cotton fibers and x-ray diffraction patters obtained from them. Note the inverse relationship between the x-ray angles, index of spiral structure, and the tensile strength.

are bound together by cellulose molecules which are not in the crystalline phase but may be bonded to the crystallites at certain points. They lie for the most part between the crystalline units in a brush heap-like structure with an occasional hydrogen bond where one molecule crosses another.

In these amorphous (non-crystalline) regions other substances than cellulose may exist. Among other things lignins, pentosans, pectic substances and waxes are very common in certain natural cellulose fibers. Certain of these materials, particularly cotton wax, may be crystallized.

The tensile strength of natural cellulose fibers varies with the arrangement of these elements in the cell wall. In general the fibrils (and therefore, the crystallites) spiral around the fiber. As the long axis of the fiber and that of the crystallites deviate from each other the arcs in the x-ray diffraction pattern resulting from the .002 plane in the crystal, for example, tend to lengthen, and vice versa. The tensile strength of cotton may be estimated from the x-ray diffraction patterns although the crystalline phase from which they are derived appears to be discontinuous, being dispersed in an amorphous matrix. The crystallites and in turn the fibrils are very long in comparison with their breadths, therefore, the friction along their surfaces may be great enough to cause rupture of the crystal when the fiber is broken. In single celled fibers such as cotton, ramie and even flax when completely defibered, an index of the strength of each type may be obtained from the spiral arrangement of the crystalline cellulose in regard to the fiber axis. The relationships are different however, for each fiber type and in the case of cottons the species and even varieties may differ.

Among the bast fibers hemp shows slightly shorter arcs, crystallites lie more nearly parallel with fiber axis, than does flax or ramie. The longer the major equatorial arcs the greater the angle

Figure 5.—X-ray diffraction patterns of hemp, flax and ramie in the order of increasing spiral angles from left to right.

between the long axis of the crystallites and that of the fiber axis and vice versa. The cellulose crystallites lie more nearly parallel with the fiber axis in the hemp than in the flax or ramie samples represented here.

The leaf, or hard fibers, contain more lignin and other non-crystalline materials thus more general background radiation in the x-ray diffraction patterns than do the purified bast fibers as used in this study. The spiral angle of the crystalline cellulose, however, may be highly organized and quite as parallel with the fiber axis as that in the bast fibers.

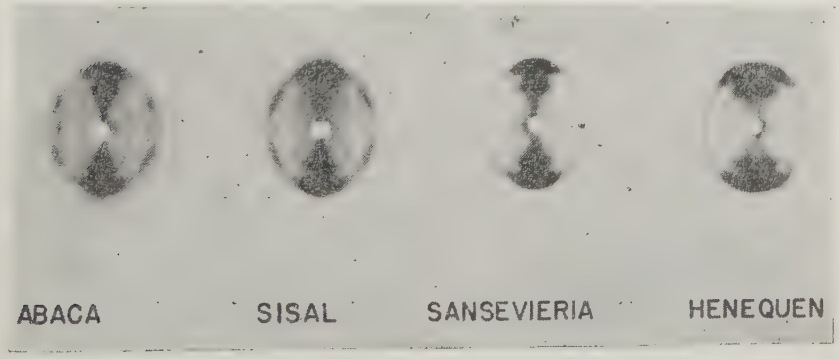

Figure 6.—X-ray diffraction patterns of abaca, sisal, sansevieria and henequen in the order of increasing spiral angles from left to right.

There is a very wide range of fiber structures particularly in the fibers used in upholstery. The spiral angle in Spanish moss is

Figure 7.—X-ray diffraction patterns of kapok, arundinaria and Spanish moss in the order of increasing spiral angles from left to right.

great enough to be resolved into two pairs of arcs one from each of the opposite walls.

Cotton, as indicated by the diagram in Figure 4, shows the greatest variation in spiral angle of any given fiber studied. The

Figure 8.—X-ray diffraction patterns and tensile strengths (Chandler bundle method) of three cottons.

x-ray angles vary from about 18° to 52° in the samples studied in the laboratory so far. These angles are only indices of the true spiral but they are indicative of the enormous differences found. Even wider differences may be expected when all the wild species of cotton are examined.

Preparation is extremely important in the multicellular fibers. In ordinary flax, jute and hemp, for example the degree of ret may influence the strength of the fiber to the extent that no relationship can be established between the structure and the strength. Similarly the condition of growth and the methods of decortication affect such fibers as abaca and sisal. All fibers are weakened by biological decay and sunlight. Since the chemical make-up of the fibers is different they respond differently to exposure to the weather, particularly

in moist places. Fibers high in lignin content such as coir are more resistant to fungi and bacteria than cotton fibers for example which have a high percentage of cellulose and no lignin. Several fibers with a high percentage of lignin tend to be stiff and harsh, whereas those composed principally of cellulose such as cotton may be firm but flexible. Ramie when degummed is essentially pure cellulose but it may be relatively stiff compared with cottons that have much larger spiral angles. The degree of crystallinity of the cellulose may also influence the rigidity of the fiber.

The spinnability and to a large extent the use value of a fiber is dependent on its shape or contour. The ratio of breadth to length is very important and determines the type and size of yarns into which the fiber can be spun. Fibers with a pronounced crimp and a rough surface felt better and can be spun into relatively stronger yarns than smooth straight fibers.

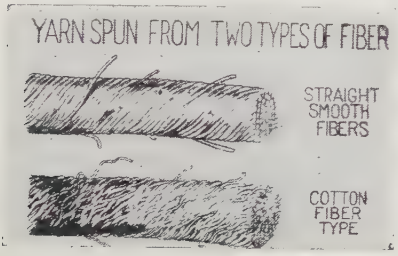

Figure 9.—Two yarns of the same diameter, one spun from smooth straight fibers and the other from crimped and convoluted cotton fibers. The fibers in the first yarn will slip when tension is applied, whereas in the latter one the fibers lock together as they become taut.

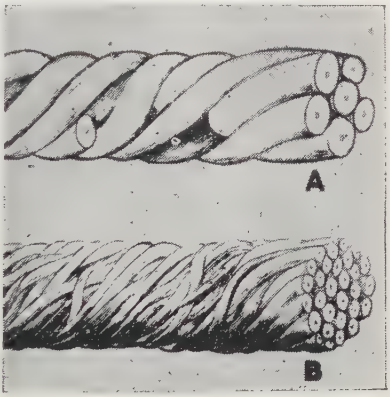

Figure 10.—Two yarns of equal size one made of coarse fiber the other of relatively fine fiber. In the latter more fibers are bound within the yarn.

The effects of fineness vary with the product being produced, but in general the finer the yarn spun the more important fiber fineness becomes. This is particularly true if the length of the fiber is limited. Mechanically more of the fine fibers are bound into the interior of the yarn than are the coarse fibers. Yarn appearance and uniformity may be influenced by the regularity of fiber size and degree of cell wall thickness as well as length. Very coarse thick-walled fibers tend to tangle with thin-walled fibers to form neps.

The surface friction may be an asset in the spinning process but if it is due to gritty substances such as residues of encrusting materials it may cut the adjacent fibers or stiffen them and cause weakness in the yarn upon flexing. For most purposes the yarns or fabrics are flexed under load or in use. In bending a member, such as a thread, one side is placed under tension the other under compression. If a fiber is rough it may bind and be ruptured rather than

slip until all elements are under essentially equal stress. Certain types of cotton fibers have a pronounced crimp, others have in addition convolutions, (auger-like twists) which reverse periodically and tend to grip adjacent fibers in a yarn and increase their felting ability.

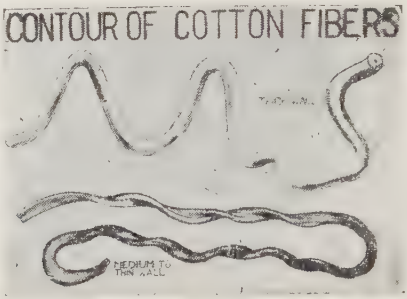

Figure 11.—Cotton fibers showing a highly crimped thick-walled fiber and one of medium cell wall thickness with convolutions.

The surface friction of bast fibers such as ramie may be regulated by leaving a residue of the intercellular material, so-called "gums" on the fibers. If they are degummed to the extent that the individual fibers are separated crimp probably will be more desirable than surface friction. Where appropriate spinning equipment is available length of fiber in ramie may overcome, to a large degree, lack of crimp and low surface friction. Long fibers can be spun with fewer turns per inch thus avoiding shear failures so disturbing in tight twisted ramie staple fibers.

The degree of ret regulates the non-fibrous material and influences to a large extent the fiber length and the spinnability of flax, hemp, and other bast fibers in textiles and jute-like fibers in burlap and rugs.

Natural cellulose fibers as shown above offer a wide variety of properties that make them especially suitable for many products. They are produced for the most part however, by small farmers or operators who cannot individually finance research to improve their quality or lower the cost of production. Should competition drive them from the market, the public in general would lose by it. Here in Florida a step forward has been made in establishing this laboratory which is being dedicated for the purpose of studying natural cellulose fibers. Let us hope that the friends of research will be patient and the scientists diligent until tangible results can be demonstrated.

RAMIE FIBER AS A SOURCE OF CELLULOSE FOR THE PRODUCTION OF HIGH-GRADE PAPER

Mr. Louis Schweitzer*

Each year there is used in this country a total of approximately 19 million tons of fibrous material for paper making. While the bulk of this is in the form of wood pulp, about a million and one-half tons of fibers are used in the form of cotton rags, linen, hemp, flax, jute and cereal straws.

I have been unable to determine exactly when ramie was first introduced in the manufacture of paper but I know that as far back as 1899 ramie has been used in the manufacture of high grade writing and legal types. We, ourselves, have manufactured small quantities of paper using ramie as far back as 1928. The ramie used by us was imported from China and was the waste product of the ramie spinning mills located in that country. We found it an excellent fiber, comparing most favorably with linen and Italian hemp which fibers we consider to be the best known for paper making. It might be well to point out that while all paper making fibers are a form of cellulose, those coming from a particular plant may have better paper making properties than others. This is because of the physical properties of the fiber itself such as diameter, length, etc. It is with papers made from high grade cotton rags, linen, and hemp that ramie must compete in price. Although ramie may be superior in certain properties to the above-mentioned fibers in the end price will be the determining factor.

Up to the outbreak of the last war, practically all linen fiber used in this country was imported from Europe, mainly from Russia. This fiber came in the form of old linen rags and waste from spinning mills. The war cut off the supply but, fortunately considerable research had been done by our organization for many years prior to the war on a substitute for the imported material. In Minnesota, North Dakota and South Dakota we found thousands of acres planted in flax. This flax was being grown for the seed which eventually was pressed for linseed oil. The flax straw, separated from the seed, had no commercial value and was burned in the field by the farmers. Research showed that this flax straw contained about 20% of cellulose fiber which was suitable for paper making. After much effort, processes were worked out to decorticate and chemically treat the fiber successfully. The result is that there is now used annually about 300,000 tons of flax straw for paper making purposes. Considering the fact that the average yield of straw per acre is about three-quarters of a ton, this means that the by-product of about 400,000 acres is now no longer a waste material having only a nuisance value but is something that is yielding a financial return to the farmer. This is an example of how research creates a new industry.

*Peter J. Schweitzer, Inc., N. Y. City. (Presented by Mr. H. F. Loring in the absence of Mr. Schweitzer).

Our own company has two decorticating plants in Minnesota for the production of cellulose from flax straw but we expect our future requirements to be double the amount of raw material we are now using. This accounts for our interest in ramie as a possible source of paper making fiber, not to replace what we are obtaining in Minnesota, but to supplement our present supply. I have been following for the past two years with great interest the work that has been done in the 'Glades in connection with the production of ramie for textile purposes, and as a result, we are about to embark on a program that may eventually take the output of about 10,000 acres of this plant. This should yield about 10,000 tons of fiber.

It would be well to understand that our problems in the use of ramie are not exactly comparable to those of people interested in the fiber for textile purposes. While the textile industry is interested in the length of fiber, tensile strength, etc., length is not important to us as eventually in our process the fiber is cut to lengths of one-quarter inch or less. We also can stand variations in the tensile strength to a greater extent than the textile manufacturers. We have no difficulty with degumming as in the chemical processes used in paper making, the gums are readily removed.

In considering ramie as a suitable raw material for our purpose, cost will be a most important factor. We must arrive at a cost that will not exceed that of our present raw materials. If we can do so, there is no question that our ramie program will develop successfully. I can foresee the possibility of anywhere from fifty to one hundred thousand acres being planted in ramie for paper making purposes.

You may be interested to know some of the problems involved in the preparation of ramie for paper making purposes. Perhaps the greatest difficulty with the material, from our point of view, is the fact that it must be decorticated practically immediately after the cutting of the plant. This is due to the fermentation that sets in. In Minnesota we have thousands of tons of flax straw which are stacked in the field and sometimes kept for a year before decorticating. This makes the decortication operation very flexible. With ramie, however, the decorticating operation must be synchronized with the cutting and everything must proceed like clock-work to be commercially feasible.

Then again, the high moisture content of the plant (about 80%) presents a difficulty as we are required to dry the fiber to a moisture content of about 10 percent before shipping. This high moisture content means that large tonnages of the plant must be handled which would not be the case if this 80 percent moisture were not present.

As there is only about 5% fiber in the green ramie plant, it is very important for us to obtain decorticating equipment which will handle ten to twenty tons of the green plant per hour. We believe we have such equipment now. About 25% of the plant consists of leaves at the top of the plant. These will be cut off before the ramie enters the decorticating machine and eventually may find their way into feed for cattle, etc. Because of the small raw fiber content there will be large amounts of waste material which will have to be

trucked away and spread over the cut fields. Fortunately, this will not hurt the fields but will serve to fertilize them.

The above is a resume of some of the difficulties involved. Now let me tell you some of the things on the favorable side of the ledger. If the operation proves successful, we will end up with a paper making fiber that possesses all of the qualities that we require for high grade papers such as tensile strength, opacity, formation, etc. It will be a material that will require far less chemical treatment than the raw material we use at present and the yield of pure cellulose from the fiber will be about 30% instead of 40% from the materials we are now using.

Our program calls for the use of one decorticating machine to approximately 1,400 acres of ramie. We are presently going ahead with the installation of the first unit. This unit will serve as a pilot plant to see if our theoretical calculations are correct and whether ramie can be produced for paper making purposes at a price to compete with other textile fibers. If this proves to be the case we hope that we will make a contribution to the agriculture of the area by helping with the introduction of a crop to the Everglades which will not be subject to price fluctuations as is the case with vegetables, but on the other hand, be one that may furnish the farmers a steady and continuous income for the years to come. If we are successful, we will introduce a new industry—the first commercial growing of ramie for use as a paper making fiber.

Previously, I had stated that there is a possibility of fifty to one hundred thousand tons of ramie being grown for paper making purposes. This belief is based not only on the ever increasing demands for high grade papers but also on the fact that there are about 100,000 tons of cotton rags now being used which eventually may disappear as a source of paper making material. The reason for this is that more and more, cotton fibers are being mixed with synthetic fibers in the manufacture of textiles. These synthetic fibers are serious source of difficulty to the paper maker as they tend to complicate the process of paper making and do not add anything to the quality of the paper, but on the contrary, have an adverse effect on its quality. The price of these cotton rags is such that it is well within the realm of possibility that they could be replaced eventually by ramie.

As you probably all know there is considerable opportunity for the utilization of the by-products of ramie decortication. Some of these are the use of the leaves for animal feed purposes, production of the chorophyll, etc. These by-products eventually may prove to be a valuable factor in reducing the cost of fiber production.

CHLOROPHYLL AND VITAMIN EXTRACTION FROM RAMIE AND OTHER GREEN PLANT MATERIALS

Mr. Jay H. Quinn*

In extracting the natural pigments from dried leaf material certain general solubility properties should be kept in mind. These general solubility properties, while subject to slight variations in actual practice, have served as the basis for plant extraction procedures, and their applicability can be noted in the procedures to be presented.

First, carotene, a hydrocarbon, would be expected to be soluble in a hydrocarbon solvent such as petroleum ether. Xanthophyll, an alcohol, on the other hand, is more soluble in a solvent containing oxygen, such as acetone or methanol. Cholorophyll, an ester, is also more soluble in the oxygen containing solvents.

Because of the plant fats and wastes which exert a mutual solvent effect, these solubilities are only generalities in actual practice.

The extraction procedures found in the literature fall into two groups. The originators of the first group of procedures were more concerned with the preparation of chlorophyll on a laboratory scale in a pure form with no regard to the amount of solvent used or the tediousness of the method. The second group of procedures apply to extraction on a commercial scale where some of the completeness of extraction is sacrificed.

The extraction procedures presented will be outlined according to these two groupings.

Laboratory Scale

A typical procedure for the isolation of pure chlorophyll was developed by Schertz (8). The procedure is essentially the same as that used by Willstatter (10) in his original work on chlorophyll.

The dried leaves are treated with petroleum ether to remove the carotene. The chlorophyll and xanthophyll remaining in the residue are removed by extraction with 80 percent acetone. Higher concentrations of acetone remove too much fatty material which subsequently interferes. Petroleum ether and water are added to the acetone solution of the chlorophyll and xanthophyll forming two layers. The upper or petroleum ether layer which contains the chlorophyll and xanthophyll is washed with water to remove the acetone. 85 percent methanol is then added with the formation of two layers. Chlorophyll in the upper ether layer and xanthophyll in the lower methanol layer. The upper layer is again washed with water until the chlorophyll finally precipitates.

Willstatter (10) in his procedure treated the dried leaves with a petroleum ether-benzene mixture removing both carotene and xanthophyll. The chlorophyll in the residue was dissolved in ethanol. Petroleum ether and water were added and the chlorophyll finally

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precipitated from the petroleum ether solution in a manner similar to the Schertz procedure.

These are the classic procedures for the isolation of the natural pigments from leaf material.

More recently a technique has been developed using chromatographic absorption for the isolation of pure chlorophyll and carotene.

Winterstein and Stein (11) used powdered sugar as the absorbent. Bakkar (1) used sugar and talc in the column. This not only leads to a pure form of chlorophyll but separates chlorophyll into two forms, an upper yellow green layer of chlorophyll B and a lower blue green layer of chlorophyll a.

Commercial Scale

The commercial applications of the extraction procedures are merely applications of the laboratory techniques with slight modifications.

Schwyzer (9) in 1930 extracted the pigments with 80 percent acetone. Most of the acetone was removd by distillation and additional water added. Talc was then added which almost quantitatively absorbed the pigments. After the talc was removed by filtration, it was washed with 60 percent acetone to remove the carotenes. The talc containing chlorophyll was dried and stored for future use.

Sattler (7) in 1936 employed benzoyl peroxide in benzene as the extraction medium. This seems questionable because of the susceptibility of chlorophyll to oxidation.

Meyer (3) in 1939 used the ordinary solvents but added calcium carbonate to neutralize the plant acids and reduce the harmful effect on chlorophyll.

Rewald (6) in 1941 used solvents of the ethylene dichloride type for extracting the chlorophyll from leaf material. The presence of free hydrochloric acid in the chloride solvents would raise some doubt as to the advisability of this procedure.

The work of Morgal, Petering, and Miller (4), (5) at the Michigan State Experimental Station published in 1941 represents a typical approach to commercial use of dried meal in isolation of natural pigments.

The meal is extracted with five portions of acetone and the extract solution concentrated to approximately 1-6 of original volume. Barium hydroxide equivalent to 10 times the amount of chlorophyll present is dissolved in water and added to the concentrate along with some super-cel filter aid. The mixture is refluxed one hour and filtered. The residue is a green sludge which may be treated in two ways. One, by adding sodium carbonate, stirring, and filtering. This results in a soluble sodium magnesium isochlorophyllin. The second treatment of the sludge involves an acid treatment leading to phytochlorine and phytochloring.

The filtrate from the saponification, containing carotene, xanthophyll, and sterols is treated with magnesium sulfate to remove excess barium, concentrated to 30 percent acetone, and filtered. The filtrate is discarded but the residue is treated with hot naphtha or petroleum ether. The residue after extraction contains xanth-

ophyll, barium sulfate, and waxes. The extract is distilled under vacuum and nitrogen to give a pure carotene concentrate.

Various other solvents have been listed in the literature for the extraction of chlorophyll. As an example, those mentioned by Lamb & Gilman (2) include cyclohexanone, methylcyclohexanone, and tetrahydronaphthalene. The boiling points of these, however, are so high that their use is not practical because of the possible decomposition of the chlorophyll during the removal of the solvent for concentration.

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Banquet and Business Meeting

Mr. H. A. Bestor,* Vice-President, Presiding

The usual business meeting was called at 8:30 p.m. immediately following the Annual Banquet held in Hotel George Washington, West Palm Beach, on the evening of April 4. The first order of business was a highly interesting lecture by Dr. Robert M. Salter, Chief, Bureau of Plant Industry, Soils and Agricultural Engineering, on "A Look Ahead in Soil and Crop Science." The complete text of this lecture is published at the front of this volume on pages 9-11, where Dr. Salter is properly acknowledged as the Guest Speaker of the Society.

Appointment Of Nominating Committee

The following Nominating Committee was appointed by the Chair immediately following the morning meeting on April 4 and instructed to report at the Business Meeting on the same evening. It was made up as follows:

Mrs. H. H. Wedgworth, Belle Glade, Chairman
Dr. Henry Harris, Gainesville — Mr. Waldo E. Lexton, Vero Beach
Mr. J. Arthur Pancoast, Miami — Mr. Alf Nielsen, West Palm Beach

Appointment Of Auditing Committee

The Chair appointed the following Auditing Committee to assist the Treasurer in Auditing the accounts of the Society at the close of the year with authority to approve same if all records were found in order:

Dr. W. T. Forsee, Chairman
Dr. R. A. Bair
Dr. R. A. Carrigan

Report Of Resolutions Committee

Mr. Luther Jones, of Belle Glade, Chairman of the Resolutions Committee, opened the discussion on resolutions by calling attention to the propriety of commending the Board of Commissioners of Everglades Drainage District for the fine work it had done practically without benefit of funds, which led to the rather pointed inclusion of this phase of the problem with the resolution which is published on page 159 of this proceedings, in the final form in which it was drawn and distributed where only one or two of many pertinent letters written and received in connection therewith appear along with it.

A second question discussed as subject matter for a resolution pertained to the need for more detailed climatological studies in South Florida especially in relation to water control operations. As

* In the absence of President Herman Gunter, State Geologist, who was ill in Tallahassee at the time of the meeting and wired his regrets on April 3rd as follows: Disappointed at not being able to be with you. Am better but still confined to my room. Regret my inability to hear the many good papers and addresses, as well as to renew friendships and make new ones. Best wishes for a most successful meeting. Signed: Herman Gunter.

finally drawn by the Committee, this resolution is published on page 163 of this volume of the Proceedings, along with certain pertinent correspondence pertaining thereto.

A third subject reviewed in quite some detail by Mr. R. J. Blank, Manager of the Palm Beach County Resources Development Board, at the request of Chairman Jones, was the need for a resolution in support of water control legislation. It was decided that Mr. Blank's statement at the close of the afternoon's program, to which the preliminary draft of a law that had been drawn to cover the field is attached and which is published on pages 115-118 of the Proceedings, should suffice for this purpose.

Finally, the Resolutions Committee was instructed by the Chair to draw an appropriate resolution of Sympathy to send to the immediate relatives of those members of the Society who had been taken by death during the year, including:

Mr. C. A. Cabell, Charleston, West Virginia
Dr. Roy Cross, Kansas City, Missouri
Mr. Johnson C. Driskell, Brewster, Florida
Mr. Bayless W. Haynes, Jacksonville, Florida
Mr. F. L. Williamson, Clewiston, Florida

Election Of Officers

The Nominating Committee was requested to report upon their recommendations for candidates to fill the Office of Vice-President of the Society and offered a single candidate in the person of Dr. Lewis H. Rogers of Gainesville, along with a motion that nominations be closed and the Secretary instructed to cast an unanimous ballot for their nominee. The motion carried without a dissenting vote.

Installation Of Officers

Following the election, Vice-President Bestor, who had been acting throughout the meetings of the day in President Gunter's absence, was duly inducted into the office of President and Dr. Gunter automatically became a member of the Executive Committee, taking the place on the Board of that occupied up to the time by former President Prof. W. E. Stokes.

Meeting Of Executive Committee
President H. A. Bestor, Presiding

A meeting of the Executive Committee of the Society was called immediately following the close of the regular business session.

Discussion was given to the meeting place of the 9th Annual Meeting, but no definite decision was arrived at either as to place or general field of subject matter to be covered.

Favorable consideration was given to the reactivation of as many of the subject matter committees of the Society as possible.

The earliest possible publication of all volumes of the Proceedings of the Society which are in arrears was urged.

R. V. Allison was named to fill the position of Secretary-Treasurer for another year.

RESOLUTIONS

SOIL SCIENCE SOCIETY OF FLORIDA

RESOLUTION COMMENDING THE BOARD OF COMMISSIONERS OF EVERGLADES DRAINAGE DISTRICT FOR THE FINE PROGRESS IT HAS MADE IN REORGANIZING THE AFFAIRS OF THE DISTRICT AND IN COORDINATING THE ACTIVITIES OF THE MANY AGENCIES WITH WHICH IT REGULARLY COOPERATES AS ORDERED BY GOVERNOR SPESSARD L. HOLLAND IN 1943; ALSO FOR THE MANY IMPROVEMENTS THIS BOARD HAS EFFECTED AND IS EFFECTING IN THE GENERAL REHABILITATION OF THE DISTRICT PRACTICALLY WITHOUT BENEFIT OF REGULARLY CONSTITUTED FUNDS WITH WHICH TO OPERATE.

WHEREAS, Governor Spessard L. Holland, with the full and unequivocal support of each and every member of his Cabinet, in public meeting in Tallahassee on April 14, 1943, ordered the Board of Commissioners of Everglades Drainage District to fully examine its authority under existing law and to go as far as possible in setting itself up as the Central Authority in developing and regulating the affairs of the District; and

WHEREAS, the Everglades Board, with the encouragement and assistance of Governor Caldwell and his aggressive theory of local self-help in all matters of government has done a remarkable job in reorganizing the District's affairs from every standpoint; and

WHEREAS, all this reorganization and rehabilitation of the Board's work and of certain limited features of its physical equipment have been accomplished essentially without funds other than the pitiably small, one-half mill (ad-valorem) tax which supplies little more than sufficient means for general, administrative expenses; and

WHEREAS, the activities of the Everglades Drainage District Board and of agencies cooperating with it, have greatly enhanced the current value of Everglades lands including those now held, as well as those sold during recent years by the Internal Improvement Fund Board; and

WHEREAS, under the Act of Congress, approved and signed by President Fillmore September 28, 1850, known as the Swamp and Overflowed Land Grant Act, upwards of 20,000,000 acres of land, including the whole Everglades area, were patented to the State of Florida with the primary objective, as expressed in the act, "That the proceeds of said lands, whether from sale or by direct appropriation in kind, shall be applied, exclusively, as far as necessary, to the purpose of reclaiming said lands by means of levees and drains ...", and

WHEREAS, the Legislature of the State of Florida, in Chapter 332, Laws of Florida, 1851, accepted the aforesaid grant and made provision for a board of internal improvement, which act was

amended by Chapter 610, Laws of Florida, 1855, granting irrevocably to said improvement board the lands received from the United States under the 1850 Swamp and Overflowed Land Act and authorizing the improvement board to "make such arrangements for the drainage of the swamp and overflowed lands, as in their judgement may be most advantageous to the internal improvement fund, and the settlement and cultivation of the land . . .", and

WHEREAS, the organic soils of the Everglades, privately owned and State lands alike, have been suffering exceedingly heavy losses ever since the initiation of uncontrolled and unregulated drainage due to lack of funds with which to develop badly needed water control plans and construct requisite works; and

WHEREAS, highly comprehensive plans for the efficient and effective handling of the water resources of the Everglades and the Conservation of the valuable organic soils of this great area are now nearing completion by the Board of Commissioners of Everglades Drainage District in close cooperation with the Office of U. S. Engineers and other Federal and State Agencies.

NOW THEREFORE, BE IT RESOLVED, that the urgent necessity for immediate rehabilitation and improvement of the existing water control system of the Everglades, and the need of funds for such rehabilitation and improvement be called to the attention of the Internal Improvement Fund Board.

BE IT FURTHER RESOLVED, that the Internal Improvement Fund Board be requested and urged to give its earliest possible and most serious attention to immediately encumbering such of its funds on hand as have accrued from sale of Everglades lands and may be necessary to meet this land development and conservation emergency.

BE IT FURTHER RESOLVED, that, prior to its publication in the Proceedings of the Society, a copy of this resolution be sent to Governor Millard F. Caldwell, and to each member of the Internal Improvement Fund Board of which he is Chairman; also to the Chairman and to each member of the Board of Commissioners of Everglades Drainage District.

By the Resolutions Committee
R. Y. Patterson
J. A. Ball
L. L. Stuckey
Luther Jones, Chairman

West Palm Beach
April 4, 1947

SOIL SCIENCE SOCIETY OF FLORIDA

Belle Glade, Florida

August 18, 1947

Hon. Nathan Mayo, Commissioner
State Department of Agriculture
Tallahassee, Florida

My dear Commissioner Mayo:

I am enclosing herewith for your consideration as a member of the Internal Improvement Fund Board copy of a resolution addressed to your Board by the Society with the hope that you may find time to give it very careful study.

In view of the exceedingly serious conditions that have developed since early in April when the Resolutions Committee of the Society was instructed to prepare this appeal for help to your Board, we are especially anxious to learn of your views in the matter.

On the other hand, through recent hearings held by the U. S. Engineer Office in Belle Glade (June 18 and August 4) the outlook for Government help with the overall water control problem is now generally regarded as more promising than it has ever been before, that is, if we can at least offer a token of self-help.

For your personal information, I am also enclosing copy of a letter to Governor Caldwell on this same subject, since I happen to know that he has long held your opinion on agricultural matters of this nature in high regard.

Sincerely yours,
R. V. ALLISON
Secretary-Treasurer

RVA:L
Enclosures

THE STATE OF FLORIDA

Department of Agriculture

Tallahassee

August 25, 1947

Dr. R. V. Allison, Secretary-Treasurer
The Soil Science Society of Florida
Belle Glade, Florida
Dear Dr. Allison:

This will acknowledge receipt of yours of the 18th, enclosing copy of your letter of the 18th to Governor Caldwell, also resolution in reference to water control in the Everglades. I shall be glad to bring this up before the Board at its next meeting.

With kindest regards and best wishes, I am

Yours sincerely,
NATHAN MAYO
Commissioner

NM:aws

TRUSTEES OF THE INTERNAL IMPROVEMENT FUND OF THE STATE OF FLORIDA

Tallahassee, Florida
August 27, 1947

Copied by request Hon. Nathan Mayo

CC: R. Y. Patterson, Clewiston
J. A. Ball, Belle Glade
L. L. Stuckey, Pahokee
Luther Jones, Belle Glade
Dr. R. V. Allison, Belle Glade

Honorable Nathan Mayo
Commissioner of Agriculture
Capitol Building

Dear Mr. Mayo:

I have examined the resolution which you handed me, transmitted by Dr. Allison, with special reference to the paragraph quoted therefrom as follows:

> "Be It Further Resolved, that the Internal Improvement Fund Board be requested and urged to give its earliest possible and most serious attention to immediately encumbering such of its funds on hand as have accrued from sale of Everglades lands as may be necessary to meet this land development and conservation emergency."

The records of the Trustees of the Internal Improvement Fund disclose:

That from 1907, when drainage operations began, till 1947, the Trustees paid toward reclamation of the Everglades a total of	$7,306,887
That during the same period, the Trustees received from the sale of land in the District, after deducting the proportionate part of operating expenses and 25 percent required by the Constitution to be paid into the State School Fund, the sum of	$5,379,437
That amount expended by Trustees on reclamation in the Everglades in excess of amount received for land in District is	$1,927,450

It is clear from the foregoing that the quoted portion of the resolution is misleading in that the Trustees have put nearly $2,000,000 more into the Everglades than they have taken out, and there are no "funds on hand as have accrued from the sale of Everglades lands."

Amounts now on hand are principally from the sale and lease of lands and oil rights outside of Everglades Drainage District, together with receipts from sand, gravel, shell, minerals, timber, et cetera.

Obligations of the Trustees, including operating and non-operating expenses, now average about $330,000 annually. During years when business is good, as from 1942 to 1946 inclusive, it is necessary

to accumulate a balance to carry over during lean years, such as 1930 to 1939 inclusive, and to break close to even during years such as 1940 and 1941. Land sales the first six months of 1947 declined 24 percent as compared with the same period in 1946.

From all of the foregoing, it is stated that the Trustees have no funds on hand derived from the sale of lands in the Everglades in excess of amounts expended by the Trustees, but on the contrary receipts show a deficit of nearly $2,000,000 under expenditures in that region.

The resolution also makes reference to the trust under which these lands are held, to-wit:

> "That the proceeds of said lands, whether from sale or by direct appropriation in kind, shall be applied exclusively as far as necessary, to the purpose of reclaiming said lands by means of levees and drains . . ."

It is clear from the foregoing that the trust under which these lands are held has been more than met by the Trustees.

Very truly yours,
F. C. ELLIOT
Secretary and Engineer

FCE/b

SOIL SCIENCE SOCIETY OF FLORIDA

RESOLUTION RECOMMENDING THE DEVELOPMENT OF MORE DETAILED CLIMATOLOGICAL STUDIES IN SOUTH FLORIDA ESPECIALLY IN RELATION TO THE EFFECT OF EXPOSED WATER SURFACES ON THE AIR TEMPERATURES AT DIFFERENT ELEVATIONS OVER ADJACENT AREAS.

WHEREAS, the development of water reserve areas in various sections of the Everglades is now rapidly coming to be recognized as a vital part of any general plan of reclamation and development for this extensive section; and

WHEREAS, an argument that is frequently advanced in favor of these water reserve areas is the effect of such exposed water surfaces on the air temperatures above them and on those over adjacent lands; and

WHEREAS, there is some observational data of a rather general nature on the above subject but little of a directly specific nature, all of which leaves us quite definitely ignorant regarding these relationships; and

WHEREAS, the fullest possible understanding of these particular climatological relationships could be of very great economic importance to agriculture and to many other important aspects of the industrial and social economy of South Florida; and

WHEREAS, the U. S. Weather Bureau of the Department of Com-

merce in Washington has a part time Meteorologist stationed in Belle Glade through the frost service period.

NOW, THEREFORE, BE IT RESOLVED, that the Soil Science Society of Florida, in regular session on this fourth day of April, 1947, recommend and urge that the U. S. Weather Bureau of the Department of Commerce give early cognizance to this need for intensive climatological studies of the relationship between winter air temperatures and exposed water surfaces.

BE IT FURTHER RESOLVED, that the Bureau be asked to develop this study as rapidly as possible including the stationing of a full time meteorologist in the area also to assist through the hurricane season in the collecting and sending out of local data and in receiving and locally distributing messages from outside sources.

BE IT FURTHER RESOLVED, that a copy of this resolution be sent to Honorable Spessard L. Holland, to Honorable Dwight L. Rogers, and to Honorable Geo. E. Smathers; also to Honorable W. Averell Harriman, Secretary of Commerce and to Dr. F. W. Reichelderfer, Chief of the Weather Bureau of that Department.

By the Resolutions Committee
R. Y. Patterson
J. A. Ball
L. L. Stuckey
Luther Jones, Chairman

West Palm Beach
April 4, 1947

SOIL SCIENCE SOCIETY OF FLORIDA

Belle Glade, Florida

August 18, 1947

Dr. F. W. Reichelderfer, Chief
Weather Bureau
U. S. Department of Commerce
Washington, D. C.

Dear Dr. Reichelderfer:

Early in April, at the time of the Annual Meetings of the Soil Science Society, there was a considerable amount of discussion of winter temperature relationships especially as associated with exposed bodies of water, whether natural or induced by storage and conservation measures. The only logical conclusion that could be reached was that we are terribly ignorant in this field regardless of its importance on the one hand and the appreciable sums that have been spent in the past on climatic research.

With the above in mind the Resolutions Committee of the Society was instructed to draw up a resolution addressed principally to your Bureau and Department, appealing for help in this connection after

discussing the problem with numerous city officials and agriculturists in a wide variety of fields who really find a very great interest in the subject once the potentialities with which it is involved are fully set forth.

In accordance with the instructions of the President of the Society and of the Chairman of the Resolutions Committee, I am enclosing copy of such a resolution herewith for your attention; also copy for Secretary Harriman, since you are in a much better position to explain the whole matter to him than could be done by correspondence in the event some member of Florida's delegation in Congress, or someone locally, may wish to contact him regarding it.

Sincerely yours,
R. V. ALLISON
Secretary-Treasurer

RVA:L
Enclosures
cc to President Bestor
Chairman Jones
Mr. Ralph Blank

UNITED STATES DEPARTMENT OF COMMERCE

WEATHER BUREAU

Washington 25
April 28, 1947

Mr. R. V. Allison,
Secretary-Treasurer,
The Soil Science Society of Florida,
Everglades Experiment Station,
Belle Glade, Florida

Dear Mr. Allison:

Your letter of August 18, conveying resolution recommending the development of more detailed climatic studies in southern Florida, is acknowledged.

The importance of the problem outlined by the Soil Science Society of Florida in the resolution is fully appreciated by the Weather Bureau and you may be sure every effort will be made to assist in its solution. However, a number of those who will be interested in analyzing the resolution are at present away from Washington, making it necessary to defer further comment until a later date. I shall be sure that a copy of the resolution reaches Secretary Harriman's office and that he is informed on the developments regarding it.

Very truly yours,
F. W. REICHELDERFER,
Chief of Bureau

RESOLUTION OF SYMPATHY

WHEREAS, death has taken from our rolls during the year the following esteemed members of the Society whose sincere and constructive interest in all aspects of the work will make their absence felt for a long time to come,

NOW, THEREFORE, BE IT RESOLVED, that this expression of sorrow over this great loss and of sympathy to the immediate families of the deceased be spread upon the records of this Society and a copy of same be sent to the closest member of the family of each.

Mr. C. A. Cabell
Charleston, West Virginia
Dr. Roy Cross
Kansas City, Missouri
Mr. Johnson C. Driskell
Brewster, Florida
Mr. Bayless W. Haynes
Jacksonville, Florida
Mr. Frederick L. Williamson
Clewiston, Florida

By the Resolutions Committee
R. Y. Patterson
J. A. Ball
L. L. Stuckey
Luther Jones, Chairman

West Palm Beach
April 4, 1947

Herman Gunter

OFFICERS OF THE SOCIETY
1946

Herman Gunter	Tallahassee	President
H. A. Bestor	Clewiston	Vice-President
W. E. Stokes	Gainesville	Member Executive Committee
R. V. Allison	Belle Glade	Secretary-Treasurer

APPENDIX

PRELIMINARY DRAFT OF WATER RESOURCES BILL
OCTOBER 21, 1946

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF FLORIDA:

Section 1. Recognizing that the water resources of the State are not being developed and utilized in an orderly, beneficial and conservative manner, that this may limit and hinder the future development of the State and is thus inimical to the general welfare, that the water resources of the State are the property of the people thereof and must be put to beneficial uses in the public interest, that existing State policies and programs do not adequately insure the wisest and most beneficial development and utilization of such resources, and that it is the duty of the State to provide the leadership and aid required to correct existing deficiencies, it is the purpose of the Legislature to hereby provide for: Full, efficient and conservative development and utilization of the water resources of the State; development of sound State water policies; collection and publication of information on the water resources of the State; preparation of unified multiple-purpose water plans based on the long-time needs of the State; coordination of water programs and activities with those relating to land and other natural resources; improved coordination of Federal and State programs; more effective cooperation between drainage districts, water conservation districts, municipalities and similar agencies and fuller participation of such agencies in long-range unified planning; and advancement of the general welfare.

Section 2. There is hereby created, as an agency of the State of Florida, the Florida Department of Water Resources, hereinafter referred to as the Department, which shall be headed by a Director of Water Resources, hereinafter referred to as the Director. The Director shall be appointed by the Governor, with the advice and consent of the Senate, shall possess broad knowledge of the development, utilization and conservation of water resources and shall be qualified by training, experience and ability to successfully discharge the duties imposed upon him by this Act.

Section 3. (a) There is hereby created a Water Resources Commission hereinafter referred to as the Commission, which shall consist of citizens of the State of Florida, appointed by the Governor; one member to be appointed from each Congressional District in the State.

(b) The term of office of each member shall be four years, except that, of the members first appointed, two shall serve for two years, two for three years and the remainder for four years. If and when any member shall remove his domicile from the Congressional District from which he was appointed, his office shall become vacant and the Governor shall fill the vacancy, within thirty days, by the appointment of another member from such District for the unexpired term, and vacancies attributable to death, resignation or other cause shall be filled in like manner.

(c) Persons appointed to the Commission shall have been citizens and residents of the State of Florida for a period of at least five years prior to the date of their appointment and shall have a knowledge of the water resources and problems of the State.

(d) The members of the Commission shall each year elect from their members a Chairman, a Vice-Chairman and a Secretary. The Chairman, or in his absence the Vice-Chairman, shall preside at all meetings of the Commission and the Secretary shall cause to be kept full and correct minutes of such meetings, said minutes to be open to public inspection.

(e) Members of the Commission shall receive no compensation for their services but shall be reimbursed, from funds appropriated to the Department, for expenses necessarily incurred by them in the discharge of their official duties; including expenses incurred by the Secretary in executing his official duties.

(f) No decision or action of the Commission shall be considered official and binding unless approved by a majority of its members.

Section 4. The Commission is hereby authorized and directed to:

(a) Lay down general policies for the guidance of the Director in administering the Department and carrying out the provisions of this Act.

(b) Review all rules and regulations prepared by the Department, and no such rules and regulations shall be promulgated by the Director until approved by the Commission.

(c) Review all plans prepared by the Department under the authority of Subsection (b) of Section 5 of this Act, and no such plan shall be submitted to the Legislature for approval or authorization as an official plan, unless and until it has been approved by the Commission.

(d) Make and adopt rules for the Government of its meetings, including the frequency, times and places of such meetings and the method of notifying members thereof, and to make and adopt rules and procedures for the transaction of its business; **provided** that the Commission shall meet at least four times in each fiscal year.

(e) Submit an annual report to the Governor reviewing its activities for the preceding year, and copies of such reports shall be transmitted by the Governor to both Houses of the Legislature.

Section 5. The Department is hereby authorized to:

(a) Conduct investigations and surveys and to otherwise collect and assemble information relating to the water resources of the State, including information on the levels of streams and other bodies of water and the flow therein, to analyze and interpret such information and to publish the results of such activities.

(b) Prepare plans, including estimates of cost and benefits, for the development, utilization and conservation of the water resources of the entire State and of regions therein for which unified regional water plans may be needed; such plans to encompass flood control, drainage, irrigation, stock watering facilities, water power, navigation, water supply and other necessary phases and to provide for the full, multiple-purpose and coordinated development of both surface and subsurface water resources; and in such plans there shall be incorporated to the fullest extent consistent with the attainment

of such multiple-purpose and coordinated development, of both surface and subsurface water resources; and in such plans there shall be incorporated to the fullest extent consistent with the attainment of such multiple-purpose and coordinated development, the plans offered by Federal agencies, other State agencies, drainage district, water conservation districts, municipalities and similar agencies, and the fullest possible use shall be made of the planning facilities of such agencies. Plans approved by the Commission, as provided by Subsection (c) of Section 4 of this Act, may be submitted to the Legislature by the Governor with a recommendation for such action as he may deem necessary to make them effective.

(c) Prepare reasonable rules and regulations to insure the proper development, utilization, control and conservation of the water resources of the State of Florida, said rules and regulations to be promulgated by the Director only after they have been approved by the Commission as required by Subsection (b) of Section 4 of this Act.

(d) Investigate undertakings that do or may adversely affect the water resources of the State of Florida, instances of improper, unreasonable, wasteful or injurious development and use of such resources, and instances of violation of the provisions of this Act or of the rules and regulations promulgated thereunder; and to take all necessary actions before executive, legislative or judicial agencies, that may be required to alter, prevent or stop such undertakings and instances.

(e) Upon the order of Court in which is pending any proceeding relating to the water resources of the State of Florida, to provide such information and render such assistance as may be requested by said Court, and at the request of said Court the Director, or any employee of the Department, may be appointed as a referee or General Master in proceedings before said Court.

(f) Review the plan for any project or facility intended for the development, re-development, utilization, control or conservation of water within the State of Florida, the cost of which is estimated to be in excess of Twenty-Five Thousand Dollars ($25,000.) or which will consume or use more than one million gallons of water per day, or the failure of which would endanger human life, and no such project or facility shall be constructed or put into operation until the Director shall have certified in writing that the plan therefore is in accord with the provisions of State law and with the rules and regulations of the Department; **provided** that such review and certification shall not be required if such proposed project or facility is part of a plan previously authorized by State law or previously approved by the Department.

(g) Under written agreements to cooperate with, advise and render technical assistance to any drainage district, water conservation district, municipality or other legal entity established by the laws of Florida, in the investigation and planning of projects and facilities for the development, utilization, control and conservation of water; and also to advise any private person, firm or corporation in such matters; **provided** that any such written agreement shall be made with and by the approval of the Commission.

(h) Cooperate and execute agreements with agencies of the

United States and other States, enter into joint investigations, surveys and planning activities with such agencies, and review the reports, plans and proposals of such agencies if they affect the water resources of the State of Florida.

(i) Hold hearings to secure factual information and to ascertain the desires and needs of the citizens of the State or any part thereof.

(j) Undertake investigations and surveys that may be called for by a resolution of either House of the Legislature and prepare reports thereon for submission to the Legislature by the Governor.

(k) Enter upon lands, structures and waters to the degree necessary to properly carry out the purposes of this Act.

(l) Employ technical, clerical and other personnel required by the Department and the Commission in carrying out the purposes of this Act, and to employ special consultants and appoint consulting boards, provided, that no consultant or member of a consulting board shall receive an aggregate remuneration for such services, not including expenses, in excess of Five Thousand Dollars ($5,000.) in any one fiscal year.

(m) Procure such supplies and equipment and rent such space as may be required by the Department and the Commission in carrying out the purposes of this Act.

(n) Receive and use in carrying out the purposes of this Act any funds, contributions, donations, gifts, or grants made available to the Department.

(o) Prepare annually a report reviewing the activities of the Department during the preceding fiscal year; and the Director is hereby directed to prepare such reports and to transmit copies thereof to the Commission and the Governor, and the Governor shall transmit copies to both Houses of the Legislature.

Section 6. (a) The members of the Commission and the Director shall, before entering upon their duties, subscribe to an oath (or affirmation) in the form prescribed for officers of this State by Section 2 of Article XVI of the Constitution.

(b) No officer or employee of the Department shall hold any other position during his connection with said Department.

Section 7. (a) In order that the water resources of the State of Florida may be most effectively developed, utilized and conserved all agencies of the State whose programs affect water resources or who can contribute substantially to the work of the Department are authorized to enter into joint investigations, surveys and planning activities with the Department.

(b) To accomplish coordination of the activities of such agencies and the Department, the Governor is hereby authorized to establish a Water Resources Coordinating Committee which shall consist of the Director as Chairman, a representative of the Florida State Improvement Commission, a representative of the State Department of Agriculture, a representative of the State Planning Board, a representative of the State Board of Conservation, a representative of the State Board of Health, a representative of the State Road Department, a representative of the Game and Fresh Water Fish Commission, and representatives of such other State agencies as the Governor may consider necessary and proper.

(c) The Director shall keep the members of the Water Resources Coordinating Committee informed of the major activities of the Department and shall call a meeting of said Committee at such times as he may consider such meeting essential, or whenever any member of said Committee shall request in writing that such a meeting be called.

Section 8. Nothing in this Act shall be construed to abolish any drainage district, water conservation district or other legal entity duly established by law nor to transfer the powers vested in such legal entities to the Commission or the Department created by this Act.

Section 9. In carrying out the provisions of this Act the Commission and the Department shall assign to the use of water for the production of agricultural commodities, including livestock, a priority second only to its use for human consumption.

Section 10. There is hereby authorized to be appropriated to the Department, out of monies in the General Revenue Fund of the State of Florida not otherwise appropriated, such sums as may be necessary to carry out the purposes of this Act.

Section 11. If any provisions of this Act shall be held invalid, such holding shall not affect the remainder of this Act.

Section 12. All Acts or parts of Acts in conflict with this Act are hereby repealed to the extent of such conflict.